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RHIZOCTONIA SOLANI IN RELATION TO THE "MOPOPILZ" AND THE "VERMEHRUNGSPILZ"

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Discussing in a recent paper ('15) the distribution of *Rhizoctonia Solani* Kühn (*Corticium vagum* B. & C.) I made the following statements:

> "It is rather surprising to find that *R. Solani* has received relatively little attention in Europe. Although recognized as inducing a disease of the potato widely distributed in central Europe, and occasionally reported on the beet, yet little careful work has been bestowed upon the fungus."

I shall now endeavor to show, as definitely as a discussion of the literature will permit, that this statement requires material modification. At the same time the evidence indicates a considerable extension of the region in which this *Rhizoctonia* is important as a seed-bed parasite. The new light on the problem is a result of the provisional determination—amounting almost to a certainty—that the Javanese "Mopopilz" and the central European "Vermehrungspilz" are identical with *Rhizoctonia Solani* (*Corticium vagum* B. & C.).

Some years ago the writer attempted to determine the possible relation of *Rhizoctonia* to seed-bed or cutting-bench diseases in Germany, but at that time the literature was scant and confusing, so that the effort was unfortunately abandoned, largely, however, as a result of the suggestions from several sources, that *Pythium, Botrytis,* and other known forms were

clearly responsible for these diseases. It now appears that a considerable literature has been gradually accumulating, but it was not correlated with the work on *Rhizoctonia,* proceeding at the same time, owing largely to incorrect determinations. I owe the present outlook upon the literature to the illuminating paper of Rant ('15[a]) in which, it would seem, from his description and figures, that he clearly and correctly identifies the "mopo" fungus of Cinchona seed-beds in Java as *Moniliopsis Aderholdii,* described by Ruhland ('08) and designated by him as the cause of seed-bed and propagation-bed difficulties. It was necessary for me to go but a step further to determine that *Moniliopsis Aderholdii* is in reality identical with *Rhizoctonia Solani.* It seems well, however, to review briefly all the contributions thus far found which seem to shed light on this fungus as a cause of disease in propagating-beds, as studied in Europe and in Java, especially as it serves to supplement the literature cited in my recent paper (Duggar, '15).

Since comments will be made in connection with the review of literature, it may be well to emphasize certain characteristics particularly distinctive of *Rhizoctonia Solani,* and among those important are the following:

(1) The great variety of higher plants affected; (2) the rapidity of spread where seedlings are attacked, presenting an appearance as if hot water had been poured over the young plants; (3) the growth of a web of mycelium over the fallen plants and likewise over the adjacent soil, so that fragments of soil adhere when the plants are lifted;[1] (4) mycelium practically hyaline when young, with characteristic branching and septation, becoming brownish with age; (5) under favorable conditions, especially in culture, the development of floccose masses, consisting of chains of cells (Monilia-like), often much branched or elbowed, colorless to brownish; (6) the formation of dark brown sclerotial bodies, irregular in size and outline, developing in the same way as the floccose masses, but denser by anastomosis, with the form of the cells (in mature sclerotia) practically uniform throughout, that is, with no dif-

[1] This perhaps more than any other characteristic enables gardeners to distinguish the fungus from the effects of *Pythium* and of *Botrytis.*

ferentiated peripheral layer; and (7) cultures readily obtained from mycelium or sclerotium, the organism producing in culture only mycelium, flake-like masses or tufts, and effuse sclerotia.

In reviewing the earlier of these studies upon diseases of this type which may be caused by *Rhizoctonia* it is hazardous to attempt to interpret those cases in which the organism is inadequately described, yet bearing in mind the more striking characteristics of *Rhizoctonia,* it is believed that no literature is here included which does not suggest this fungus. In the later studies the organism has been for the most part so well described that little doubt may be entertained with respect to the determination. For the present it is necessary to rely upon a discussion of the literature, but when more material, in the form of cultures, from the regions here referred to is available, a supplementary statement will be required.

An examination of the files of the more important of the horticultural journals of both France and Germany prior to 1880, has been made with the result that references to diseases of cuttings and seedlings are found to be not infrequent, but without exception these contribute nothing, so far as I have been able to find, which will throw light upon the organism concerned. The earliest reference which has been found to be of importance is that of Therry and Thierry ('82). They reported having studied, for more than a year, the mycelial filaments which invaded the cutting-benches of gardeners and florists in the region of Lyons. Although unable to find a spore stage, they described the organism studied as *Mortierella arachnoides* Th. & Th. (araignée des serres), since they considered the vegetative stage to show a close relationship to *M. Ficariae* which they found on leaves of *Ficaria Ranunculoides. M. arachnoides* is described as killing the shoots and growing over the fallen tissues, disorganizing them with great rapidity, also growing over the soil in the form of a web of strands. The mycelium is said to be able to grow meters during a single night. The points noted, together with the brief description of the mycelium, strongly sug-

gest *Rhizoctonia,* and it would not be strange that sclerotia were absent under the conditions.

Prompted apparently by the account just referred to, and based somewhat upon that, von Thümen ('82) reports upon the "Vermehrungspilz," and this appears to be the first definite account of the organism from central Europe. His description of the mycelium adds somewhat to that of Therry and Thierry, and like them he found that "* * * die Untersuchungen nichts weiter ergab, als die Anwesenheit zahlreicher, spinnwebendünne, weisslicher oder bräunlicher Mycelfäden, von irgend einer Fructification aber trotz genauesten Suchens auch nicht die mindeste Spur aufzufinden war." Whatever may be the interpretation of these two sets of observations they emphasize (1) the rapidity of growth and violence of the attacks of the organism concerned and (2) the presence of a mycelium as the only stage of the associated organism.

It appears probable that the disease which came to be known as "maladie de la toile" in France is the same as that referred to by Therry and Thierry ('82); nevertheless, such observations as are reported during the next fifteen years leave the question of a causal organism in an unsatisfactory state. Mangin ('94) refers to "la toile" as the disease due to a fungus occurring both in the greenhouse and in the open, producing a decay of leaves and branches, especially at or near the surface of the soil. Recalling what has already been said regarding this fungus it is significant that he remarks: "Quand la *Toile* est bien développée, les filaments mycéliens agglutinent les fragments de terre et deviennent très visibles." Collecting material from the affected area he found that in a few days conidiophores of *Botrytis* appeared on the dead leaves. With cultures of the *Botrytis* he reproduced a disease in lettuce. Since, however, *Botrytis cinerea* might occur upon any debris, and since it also produces a disease of lettuce, it does not follow, of course, that it is the fungus responsible for the troubles here referred to. From the description of the effects, one is inclined to reject the idea that *Botrytis* is concerned in this case. In the same year Prillieux

and Delacroix ('94) found "la toile" abundant in the seed and propagating-beds, market gardens, etc., near Fontainebleau. Affected plants were infested with a sterile mycelium, and they found a fungus, identified as *Botrytis cinerea,* fruiting on the dead material, from which they prepared cultures. No infection experiments were made, and they report no attempt to ascertain if the mycelium in the tissues were really that of *Botrytis.* No additional information is advanced in Mangin's ('94[a]) second paper.

Sorauer ('96) refers to the "Vermehrungsschimmel" of the cutting-benches and of seed-beds as probably belonging to the genus *Sclerotinia.* Reference is made to the spider web-like mycelium, lack of sporophores, and the presence of sclerotia. It is apparently on account of the sclerotia that he refers the fungus to *Sclerotinia.* He indicates that this organism is the chief fungus of the cutting-bench, although *Mucor, Botrytis,* and other organisms may also be found. The description, though far from being complete, is applicable to *Rhizoctonia.*

Aderhold ('97) characterized the fungus and its effects in some detail, and there can be little doubt that he was dealing with the disease then recognized as widely distributed. Moreover, unlike those who preceded him, he obtained the sterile fungus in culture, observed the Monilia-like chains of cells, and also the formation of sclerotia. It seems remarkable that it did not suggest to him Kühn's potato fungus. On the contrary, he agreed with Sorauer in referring the fungus to *Sclerotinia,* without indicating the species.

In a second paper Sorauer ('99) also discusses the fungus more completely. He refers to much of the earlier work, including that of Aderhold. Various stages of the fungus are figured, that is, the mycelium, the moniliform hyphal cells, and the sclerotia, all stages pointing to *Rhizoctonia.* He also refers to a characteristic of his fungus, since frequently observed, doubtless, by all who have studied *Rhizoctonia* in liquid cultures, namely, that of growing up the walls of the vessel above the level of the liquid. He also examined the affected tissues and was able to follow the mycelium in its advance, showing its penetration into the inner bark, like-

wise into the mesophyll of affected leaves. Comment is made on the fact that the death of the cells ensues when very few hyphae have penetrated the tissues.

A review of the earlier work on "la toile" in France is presented by Beauverie ('99) who calls attention to the fact that the fungus producing this disease has been considered by some to be *Botrytis cinerea,* and by others to be *Acrostalagmus albus,* a determination made in one instance at least by Oudemans ('92). This determination was based on material received from the Zoölogical Garden at Rotterdam. Beauverie obtained cultures but fails to describe how the fungus was isolated. From these cultures he was able to obtain only a sterile fungus, which, unfortunately, is not described. Failing to obtain spores he then proceeded with cultures originating from *Botrytis cinerea.* By growing this organism in a moist atmosphere at a temperature of about 33°C. a sterile form was induced. Again, by exposing cultures to a temperature somewhat lower, he affirms that he was able to develop a temporary sterile stage. It would appear that on the basis of these results he draws the conclusion that the first organism isolated represented also a sterile form of the *Botrytis.* He further emphasizes the point that the sterile form is the more dangerous in the production of disease, leading to the inference that conditions resulting in the development of this stage predetermined the prevalence of the malady. It is unsatisfactory to attempt to draw conclusions from this work, but it is at least probable that his first cultures may have been *Rhizoctonia,* and that, however accurately the work with *Botrytis* may have been carried out, it had really no connection with "la toile."

Lindau ('08) follows his discussion of *Rhizoctonia* with a paragraph dealing with the fungus producing disease in the cutting-bench and propagating-houses. The organism is described on the basis of the observations of Sorauer ('99) and Aderhold ('97), reference being made to the characteristic mycelium and chains of short cells, as well as to the occurrence of sclerotia. He questions the relationship with *Monilia,* sug-

gesting that the figures would indicate a closer relationship to *Hormiscium* or *Torula*. Since many of the American studies upon the potato and damping off fungus had previously been examined by him, as the account of *Rhizoctonia* indicates, it is surprising that the possibility of the identity of the "Vermehrungspilz" with *Rhizoctonia* was not suggested.

In his discussion of the fungus Ruhland ('08) considers the earlier work of Aderhold, Beauverie, and Sorauer. Special attention is given to that of Beauverie, and Ruhland takes the view that while in all probability the disease discussed by that investigator is the same as the disease of propagating-beds in Germany, Beauverie's cultures of *Botrytis* were not those of the disease-inducing organism. Ruhland studied the organism in culture, confirms the previous descriptions of mycelium, Monilia-like cells, structure of the sclerotia, etc. He would regard the sclerotia as sclerotial-like bodies (pseudosclerotia), owing to the fact that the structure is homogeneous throughout. Cultures of the fungus here discussed and of *Botrytis cinerea* were studied in parallel series with respect to the capacity to ferment cellulose, and it was found that while this capacity is possessed to a considerable degree by *Botrytis,* as had been previously established, the cellulose-dissolving capacity of the "Vermehrungspilz" is very low. He finds that in the development of the Monilia-like cells there is only a superficial resemblance to *Monilia,* since the spores of the latter are produced basipetally, while those of the seed-bed fungus are formed acropetally. The development of sclerotia from the Monilia-like masses is also noted. Apparently, he concluded that the old cells of the Monilia-like chains, as well as those of the sclerotia, were empty, hence incapable of germination. Earlier studies of *Rhizoctonia* have, however, shown clearly that many old cells of this type are capable of germination, and the peculiarities of this process have been figured and described (Duggar, '99).

In Java a disease of the Cinchona seed-beds was reported by Moens ('82). He describes the damping off of the seedlings as rapidly progressing radially, especially when the conditions are moist. The disease often begins at those points

where the drip from the defective roof falls on the seed-bed. The mycelium is described as spreading rapidly in the form of a web over the diseased plants and adjacent soil. Some observations were made by Stibbe ('06) who also reported that the disease may appear as early as during the first few days of growth. Koorders ('06) observed the disease in a young plantation. An examination of affected stems and roots was made, and a colorless, septate mycelium was found, but there were no evidences of fruiting stages. From these earlier observations of the Cinchona diseases in Java we have only the above evidences of the effect upon the host to suggest *Rhizoctonia* or a related fungus.

The investigations of Rant ('08, '14, '15, '15[a]), previously referred to, are sufficiently complete in all particulars to enable us to identify the fungus as *Rhizoctonia.* To this disease he applies the term "mopo" and "hamamopo" rather than the Dutch "Schimmeldraadjes." He found the effects upon the host to be as previously described, and noted particularly that the cobweb-like growth of the mycelium over the soil and dead plants occurred in a characteristic fashion when the area over the seed-bed was moist. He also emphasizes the point that fragments of soil are firmly held together by the growth of the fungous mycelium. Referring again to the distinctive characteristics of *Rhizoctonia* enumerated earlier, we find that his work covers every point there indicated. The fungus was found to affect not only Cinchona seedlings but was also found in his garden upon the following: *Lychnis diurna, Rudbeckia sp., Lobelia erinus, Conyza angustifolia, Bidens pilosa, Antirrhinum majus,* red beet, endive, cabbage, and lettuce. Culturing the fungus upon peptone glucose agar he obtained a good growth with all the characteristics of *Rhizoctonia* which have been referred to in my previous paper. Comparing his measurements with those previously reported, it is found that there is a close agreement throughout. The measurements also agree with those of Aderhold ('97). Rant also instituted a comparison between this fungus and *Botrytis cinerea,* and the results well emphasize the differences between these two organisms. He found likewise that the

"mopo" fungus bears no resemblance to *Acrostalagmus albus*, to which "la toile" in France had been occasionally referred. On the other hand, cultures of the "Vermehrungspilz" obtained from Amsterdam agreed closely with the organism isolated from Cinchona seedlings. Infection experiments with the "mopo" fungus were carried out both on Cinchona seedlings and on seedlings of the plants previously enumerated as affected. In all cases positive results were obtained.

Summary and Discussion.—From the reviews and discussion it seems justifiable to conclude that the common seedbed fungus in Germany and in France is identical with the damping off fungus which has been frequently studied in this country since the investigations of Atkinson ('92). I have given the evidence upon which the conclusion is based that the damping off fungus of the United States is Kühn's *Rhizoctonia Solani* (*Corticium vagum* B. & C.), the cause of important potato diseases and of other types of disease in a variety of host plants. The work of Rant enables us to include in this category of diseases due to *Rhizoctonia Solani* the disease of Cinchona seedlings and of other plants in Java. In establishing these points it is not necessary to consider the earlier and less complete reports upon "la toile" and the "Vermehrungspilz" but particularly the papers of Aderhold ('97), Sorauer ('99), Beauverie ('99), and Ruhland ('08).

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THE TEXAS ROOT ROT FUNGUS AND ITS CONIDIAL STAGE[1]

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More than twenty-five years ago Pammel ('88, '89) spent two summers in Texas investigating an important cotton disease popularly known as the "cotton blight" or "cotton dying," and as a result of his observations two reports were published upon the cotton root rot,—the latter more appropriate name being applied by him to the disease in question. He determined the causal organism to be a sterile fungus found in some abundance on every dead or dying root, and it was tentatively identified as *Ozonium auricomum* Lk. After a study of Link's type, Shear ('07) described the organism as a new species, *O. omnivorum*.

Since the work of Pammel the disease has doubtless been the object of numerous field observations, more or less extensive, but so far as is personally known to me, and so far as reports are available, the only records are those of Duggar ('09, observations made '01, '02), Shear ('07, observations beginning in '02), Shear and Miles ('07, '07[a]), Heald ('09, '11), and Heald and Wolf ('11, '12). The disease is undoubtedly one of the most destructive of the cotton fungi, and the average losses sustained in the state of Texas have been variously estimated by Orton ('06) and others to be two to three million dollars. In addition, considerable damage is sustained by such crops as alfalfa, beans, sweet potatoes, and certain orchard fruits.

It would appear that the organism is very largely confined to Texas. In that state it seems to have been commonly ob-

[1]The writer was engaged in a study of cotton diseases, especially the Texas root rot, in the Bureau of Plant Industry during the seasons of 1901–02. In the fall of 1902 the work was transferred to Dr. C. L. Shear. Now that the Missouri Botanical Garden is giving special attention to a botanical survey of a certain section of the Southwest, it has seemed appropriate to resume the studies of this fungus so wide-spread and destructive in a large part of that region.

served since 1866. Shear ('07) states that the fungus is distributed from eastern Texas to southern California, and that it has been found in southern Oklahoma and Indian Territory. The writer failed to find the organism in western Louisiana and southwestern Arkansas in 1901, but it was observed in southern Oklahoma in 1915. I am unaware of the data on which the occurrence of the fungus westward to California is reported. Nevertheless, considering the long period of time during which the *Ozonium* has been a serious disease-inducing factor in Texas, it is rather remarkable that it has not been found in Louisiana and Mississippi. In these states the cotton wilt fungus, *Fusarium vasinfectum,* is well known, but the *Ozonium* has never been reported, so far as can be learned. It is almost impossible to assume that the fungus has not been distributed to these states through the various possible commercial channels; so that one is impelled to draw the inference that the establishment of the fungus farther eastward is limited by climatic or soil factors.

It should be recalled that Pammel reported the disease common throughout all sections of Texas in which cotton was grown, with the exception of the gulf prairie region and certain alluvial soils. It seems now certain that there is no soil type in the cotton-producing section of the state which is free from the disease. Nevertheless, the percentage of loss has been invariably greater in the black prairie or black waxy soils, whether with or without outcroppings of rotten limestone. As noted later, the organism occurs on a number of native plants, both trees and herbs, but the observations thus far made give no clue as to whether or not it may be considered endemic. I have been unable to secure data on the occurrence of this fungus from Mexico southward.

From the reports of Pammel, Heald, Heald and Wolf, and from my own observations, the following host plants may be enumerated.

Trees and shrubs: *Ulmus americana, Broussonetia papyrifera, Morus alba, Ficus Carica, Acer saccharinum, Tilia americana, Fraxinus americana, Diospyros Kaki, Melia Azedarach, Pyrus communis, P. Malus, Cydonia vulgaris, Robinia Pseudo-Acacia, Prunus Persica, P. sp.* (cherry), and *Hibiscus syriacus.*

Herbaceous plants: *Beta vulgaris, Chenopodium sp., Cassia Tora, C. marilandica, Medicago sativa, Arachis hypogaea, Phaseolus vulgaris, Vigna sinensis, Linum rigidum, Croton spp., Euphorbia spp.* (three), *Sida spinosa, Hibiscus esculentus, Gossypium herbaceum, Petroselinum hortense, Ipomoea Batatas, Solanum rostratum, Ambrosia psilostachya,* and *Xanthium canadense.*

So far as I am aware, no special attempt has been made to determine all the species of wild herbaceous plants or forest trees affected. The enumeration of hosts given above makes it seem plausible, therefore, that few plants or crops may be free from the disease except the grains and other members of the grass family. At Petty, Texas, in September, 1901, the disease was found upon half a dozen species of weeds in a pasture, the sod of which could not have been disturbed for some years previous.

The chief characteristic of the disease, as far as I have observed it on herbaceous plants, is the sudden wilting and dying of the affected individuals. Occasionally a slight yellowing and unhealthy appearance is found to be due to an infection which does not encircle the main root, and less frequently to the localization of the disease in a few of the larger primary root branches. The first "dying" of cotton is associated with the beginning of blossoming, or of boll formation, commonly from June to July; but Pammel reports one case in which the disease was observed May 6. If the fungus is responsible for injuries in the early stages of growth, then either such injuries have been overlooked or have been ascribed to other causes.

In common with *Rhizoctonia Crocorum* the organism spreads radially, the rate of spread being most variable and, of course, governed by the conditions. The most rapid spread observed by the writer was in a field of irrigated alfalfa. The persistence of the larger "dead spots" season after season in much the same part of the field is accountable in large measure for the popular belief that these are "alkali" spots. The progress of the disease from one year to another is best followed by observing a perennial crop such as alfalfa, in which case new infections are usually relatively few, whereas in a field grown two years or more to cotton

one notes the disappearance of some of the smaller spots of the previous year, and often the number of new infections is considerable.

If diseased cotton stalks are left standing in the field, few or no evidences of the fungus are apparent on the roots the following March. However, some of the more interested growers claim to have observed mats of the fungus turned over by the plow when bedding the land. I have been unable to obtain such material for study. As already indicated, the reappearance of the larger spots, particularly, is a strong indication of the persistence of the mycelium in the soil. This leaves out of consideration the influence of the conidial stage, discussed below, in the persistence of the organism in the same area during successive years.

On lifting wilted stalks of cotton, or stalks recently dead, it is found, from the most favorable material, that the roots are closely invested with a cinnamon-buff[1] felt of hyphae in which strands are conspicuous. The fungus may involve the smallest rootlets, and in addition, the strands of hyphae penetrate the soil and apparently extend considerable distances. The larger soil strands are somewhat darker, often cinnamon-colored. In a badly infected area the strands of hyphae may be found in any lump of soil. Pammel describes the mycelium as brown in color, and Shear as "dirty yellow, whitish when young." In the early stages of development on the host, I find the mycelium pale buff, becoming cinnamon-brown as strands are formed.

In September, 1915, the conditions were particularly favorable at Paris, Texas, for late-season infections, so that by examining the roots of many plants taken at the periphery of a diseased area, but themselves apparently healthy, comparatively early stages of infection were observed. In all cases a depression of the bark pointed out the area of penetration of the fungus on the main root. The observations also demonstrated clearly that the attack may be either what I shall designate centripetal or centrifugal. In the former case the infection converges upon the main roots from a few or many small laterals, while in the latter the main root may be com-

[1]Ridgway's 'Color standards and nomenclature' has been employed in the determination of all colors referred to in this paper.

pletely encircled before the fungus extends to the branches. If recovery of affected stalks occurs at all, it is usually by the production of very superficial laterals.

I have not made a careful study of the distribution of hyphae in the various tissues, nor of the mechanism of penetration. From the variety of plants affected it may be inferred that direct infection by the hyphae is general. The presence of lenticels on the enlarged part of the root of cotton by midsummer may possibly be related to the greater susceptibility of this plant, and may also be a factor in determining the frequency of the centrifugal type.

During the seasons of 1901–02 a careful search was made for spore stages of the *Ozonium,* and while several basidiomycetous fungi were found on old cotton stalks in areas where cotton had died from the disease, still no case was observed which, upon careful examination, proved worthy of experimental study. In the examination made of such material special care was given to the characters of the mycelium. However, while examining a semicircular area of dead cotton on the edge of a cotton field in 1902, my attention was caught by a buff-colored circular spot on the ground just outside the cotton field in an area of grass and weeds wherein several of the latter had died from the *Ozonium.* The material observed proved to be an incrustation, or light powdery layer, of spores covering about one square foot in area. One small area of a few square inches only, considerably weathered, was found between the rows of cotton. Removing the soil with some of the spore material and making an examination under the hand lens it was found that strands of the *Ozonium* pervaded the whole mass, and thus there was presented the possibility of a spore form genetically connected with the *Ozonium.* Subsequently, the spore material was studied more carefully. At that time it was clear that strands of the *Ozonium* were present under the masses of spores, but the observations afforded no evidence of the method of spore production. The masses of small spheroidal spores formed a layer sometimes 3 mm. in thickness, and while the broken bits of hyphae observed resembled those of the *Ozonium,* no light was thrown on the relation of spores to mycelium. The conditions so much resembled those under

which oidial formation occurs in cultures of certain *Basidiomycetes* that I subsequently suggested the presence of such an oidial stage of this fungus (Duggar, '09). Owing to the transfer of the cotton disease work to Dr. C. L. Shear at this time the material was laid away, and not again examined until a recent reinvestigation of all material in my hands which might be considered related to *Rhizoctonia*. Then it was ascertained that the best packet of material collected in 1902 had not been studied—that from the area found between the rows of cotton. The reëxamination of this collection resulted

Fig. 1. *Phymatotrichum omnivorum:* types of conidiophores and conidial production.

in finding in some abundance the hyphae which bear the spores. It was furthermore ascertained that the spores were produced at first on the characteristic larger hyphae and on small branches of those hyphae which make up the strands of the fungus in the soil. Typically, the attached conidia were found in heads about short swollen, but not necessarily spherical, branches of the short-celled or strand hyphae. These branches were simple or forked, the forking being at irregular intervals, and occasionally branching was continued from a swollen cell (fig. 1). The spores adhered some-

what, but never in such masses as characterize certain species of *Sporotrichum* or *Verticillium*.

In view of the importance of this observation, and failing to secure material from correspondents, a trip to Paris, Texas, was arranged in September, 1915, with the view of securing fresh material and of making further observations on the fungus in the field. The time selected proved favorable, and an examination of the cotton fields in the vicinity of Paris revealed the *Ozonium* in unusual abundance. Nevertheless, "dead spots" in many fields were examined before the characteristic fruiting stage was found. Then it was located in some quantity in a "dead spot" of about one acre in extent, occurring in a very rich, black waxy soil in a low-lying area of the field. In this area no less than a hundred or more of these conidial circles were found. They varied in diameter from 3 to 30 cm. The majority of these were found in the furrows or "middles" between the rows of cotton, yet they also occurred on the ridge rows, and in seven cases they encircled diseased cotton stalks. In the latter cases, however, the strands penetrating the spore-bearing layer appeared to come from the soil in general rather than directly from the diseased root. In every case the typical color of the spore mass was light pinkish cinnamon, and in thin strata pinkish buff, fading somewhat on drying. At that date the circular area consisted of a more or less perfect crust of spores sometimes broken or powdery. A few of the spore areas had become overgrown with such olive-green moulds as *Cladosporium* and *Macrosporium*.

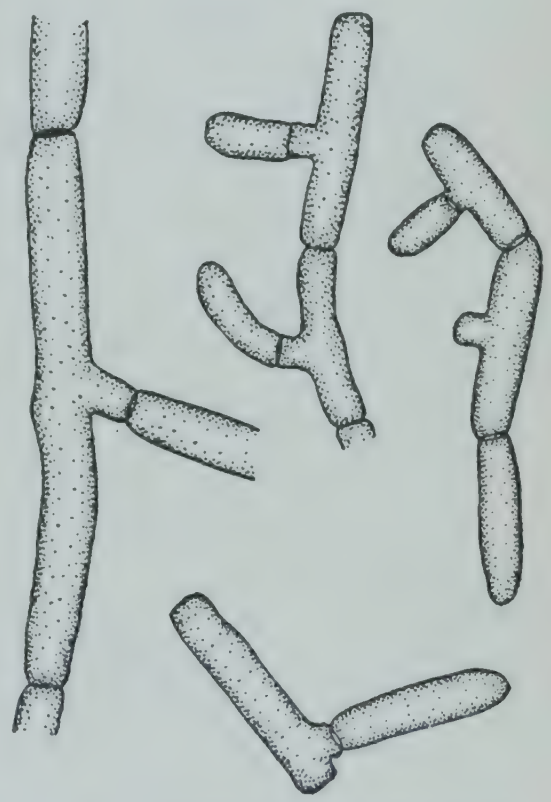

Fig. 2. *Phymatotrichum omnivorum:* large-celled hyphae.

Just below the spore crust, especially towards the center, the typical cinnamon-buff strands of the *Ozonium* occurred in abundance. A similar type of mycelium also permeated the soil to a considerable extent in the immediate vicinity and often about the periphery of the spore-bearing area.

The study of the collections made in 1915 emphasize the diversity in the form of hyphae as well as in the method of spore production. Although no circular areas were found in an early stage of development, yet some of the older ones yielded on the periphery material from which the method of spore formation could be followed. It would appear that a superficial growth of large, branched, almost hyaline hyphae is first formed (fig. 2), covering the surface with a delicate stratum. These hyphae are sometimes Rhizoctonia-like. They may also bear conidiophores at irregular intervals, the latter arising usually as short assurgent branches. These branches either produce conidia directly, or commonly after becoming variously forked (fig. 1). As further growth proceeds, however, definite strands are developed, and then swollen branches from any cell of the strand may produce spores. Later the wave of spore production appears to involve practically the whole mycelium, and the conidia are found laterally distributed in various positions on the surfaces of both the strand and simple hyphae, so that in the end there is practically nothing left but a pulverulent mass consisting of the conidia and remains of the mycelium and strands. The conidia are sessile, but occasionally cells bearing conidia exhibit a somewhat roughened surface. The true character of the fungus cannot be determined unless one is careful to secure the youngest material available, that is, from near the margin of the spore area, or otherwise a spore-forming area in an early stage of development.

The diverse characteristics of the mycelium, as found on the surface of the host and in the soil, may be briefly summarized as follows:

(1) Large-celled type. Hyphae Rhizoctonia-like, often abundant on the margins of the conidial areas, measuring frequently 20μ in diameter, with cross walls 60–120μ apart. This type should also include some of the arachnoid mycelium

on the surface of the roots, also those representing early stages of strand formation (fig. 2).

(2) Strand hyphae. In these the individuality of the hyphae is practically lost, the strands being ultimately plectenchymatic bands in which the individual cells vary considerably in diameter, the larger cells of young strands resembling somewhat the larger hyphae above mentioned. It is interesting to observe that they may serve not only to spread the fungus vegetatively, but superficial soil strands may function as a conidial stroma. They are also more or less sclerotial and are doubtless an important factor in the persistence of the fungus in the soil (fig. 3).

(3) Acicular type. The arachnoid mycelium with which the root is invested gives rise to certain fairly rigid hyphae

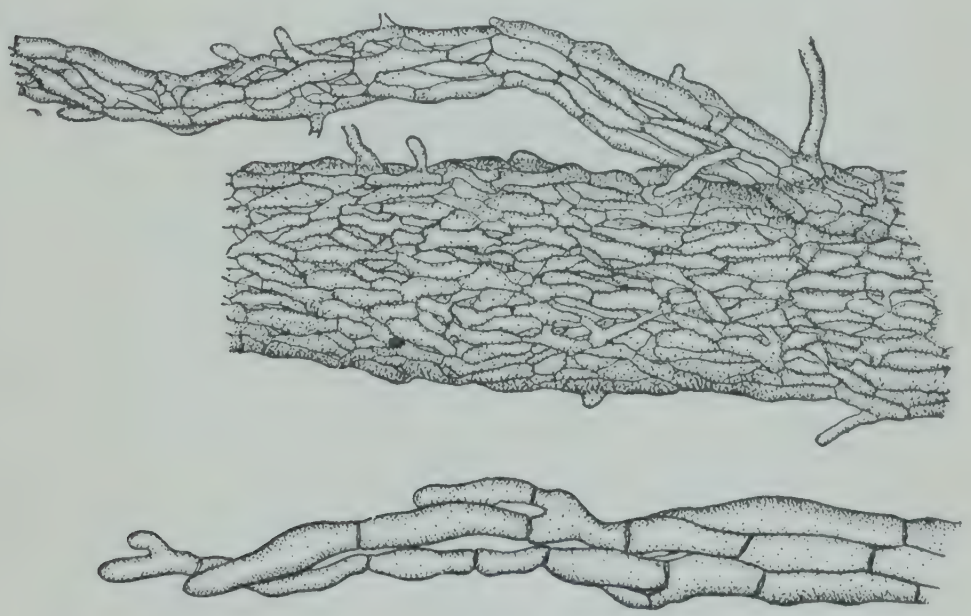

Fig. 3. *Phymatotrichum omnivorum:* mycelial strands; upper, old strand from root of cotton; lower, young strand from conidial area.

which in turn produce branches that are most frequently in pairs, that is, opposite, and at right angles. Branching is also not infrequently verticillate. In all cases such branches are characteristic in appearance, being rigid and needle-like, tapering to very fine filaments (fig. 4). This type has been found only on the roots.

It is necessary to add, however, that intermediate types between the various forms mentioned occur. In general, the

mycelium is Rhizoctonia-like rather than Ozonium-like, yet no sclerotia have been found. In this connection I may add that it is proposed in a later paper to bring together certain observations which have been accumulating on Ozonium stages of *Basidiomycetes*.

Numerous germination cultures have been made with material from two weeks to three months old. While this has afforded some interesting suggestions, germination in any particular medium has been, on the whole, erratic. The data are

Fig. 4. *Phymatotrichum omnivorum:* acicular hyphae exhibiting characteristic modes of branching.

reserved for a later report. The cultures which have been prepared from the newly infected root, as also those from erratic spore germination, have yielded a sterile mycelium which, while in itself distinctive, resembles only in a general way the mycelium found on the roots and in the soil. The mycelium in culture is hyaline, forming on young bean stems and on various other culture media a dense, slow-growing mat, seldom rising more than 3 mm. above the substratum, and never becoming fluffy in appearance. After standing for some weeks this mycelium becomes somewhat colored, assuming a warm buff to light ochraceous buff. In culture the

hyphae are likewise most diverse in diameter, varying from those 15–20μ to others extremely delicate and flexuous (fig. 5). No truly acicular branches, however, are produced under ordinary cultural conditions. With age, the mycelium somewhat collapses toward the substratum and has a greater tendency to grow along the glass tube in the form of false strands. Grown in soil, by covering a vigorous growth on bean stems with a layer of loam, hyphae similar to those just described are produced; but, in addition, there are formed here and there vesicular enlargements, and the latter are sometimes

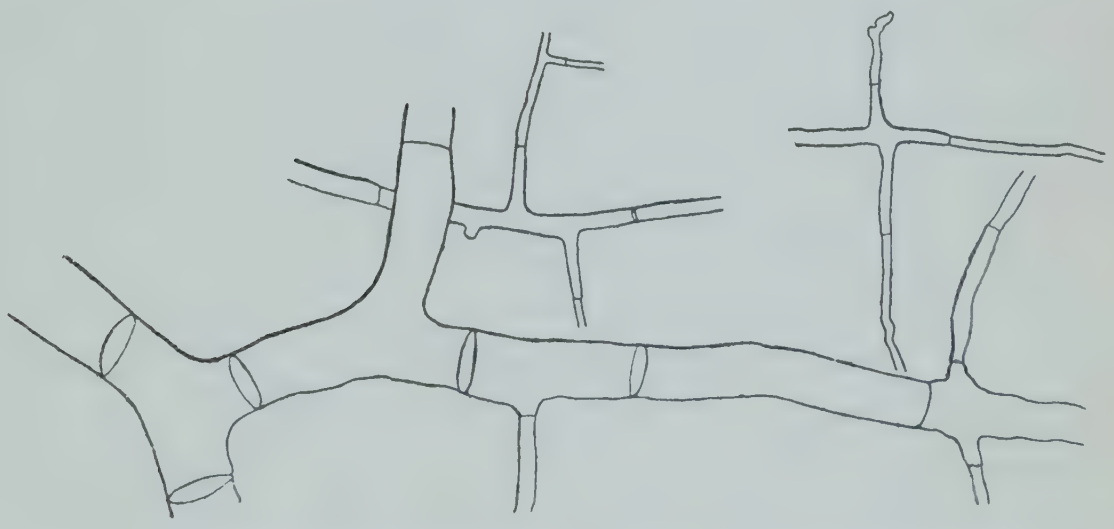

Fig. 5. *Phymatotrichum omnivorum:* hyphae grown on bean stems, from a culture 60 days old.

in clusters, the branches becoming two to three times forked. The conditions for conidial formation have not been determined.

It will be seen that the connection of the conidial stage with the *Ozonium* rests at present upon two classes of observation: (1) the presence in the conidial layer of hyphae and strands (bearing conidia) found to be identical with the characteristic mycelium on the roots of affected plants, and (2) the identity in artificial culture of the mycelium originating, on the one hand, from diseased roots, and, on the other, from the germination of the conidia. To complete the proof it would, of course, be necessary to secure positive results by inoculation with conidia, or better, positive results with a pure culture originating from conidia. Unfortunately this phase of the work has not been successfully developed. In

this connection it should be said that no inoculations carried out in the greenhouse up to the present have given positive results. As a source of infection I have employed (1) diseased cotton roots fresh from the field (showing the *Ozonium* in abundance), (2) fresh conidia, and (3) cultures from diseased roots. It is apparent that the conditions for infection have not been made satisfactory. Such experiments are to be continued both in the greenhouse and in the field.

It has been found difficult to place the fungus satisfactorily in any established genus of the *Hyphomycetes*. While in the manner of conidial production it is undoubtedly related to such genera as *Phymatotrichum, Botryosporium, Rhinotrichum,* etc., it does not exhibit all the characteristics of any of these genera. Nevertheless, it has seemed best, after examining all available exsiccati material of forms which might be related, to place the fungus tentatively in the genus *Phymatotrichum,* and, if Bonorden's figure (Handb. d. allgem. Myk. *pl. 8, f. 181*) is correct, fairly close to *P. pyramidale* Bon.[1] The fungus is clearly excluded from *Botryosporium*, the conidiophores of which are erect, with conidia produced on sterigmata. Slightly emended, the genus *Phymatotrichum* would be of taxonomic convenience. In placing the Texas cotton fungus in this genus, I would not convey the impression that this fungus is considered to belong to the *Ascomycetes*. Accepting Shear's specific name, a revised description of the organism is appended.

Phymatotrichum omnivorum (Shear) Duggar, n. comb.

Hyphae diverse, forming on the host (1) a loose weft of large, branched cells, producing more rigid hyphae with acic-

[1]It should be noted that the genus *Phymatotrichum* Bonorden (Handb. d. allgem. Myk. p. 116. *pl. 8, f. 181.* 1851) was at first reduced to a section of *Botrytis* by Saccardo (Sylloge 4:134. 1886). Later, however, he restored it to generic rank (Sylloge 16:1033. 1902) to accommodate a species of Oudemans. Costantin (Les Mucédinées simples, pp. 44–46. *f. 12.* 1888) gives a detailed description of a fungus, which was obviously considered *Phymatotrichum pyramidale* Bon., under the name *Botryosporium pyramidale* Cost. There can be little doubt that the fungus figured by Costantin is properly placed. However, the source of Costantin's material was apparently not the original specimen of Bonorden, and since his figure differed in many respects from that of Bonorden, it is perhaps fair to question the identity of the two fungi. Lindau (Rabenhorst's Kryptogamenflora 1 (Abt. 8):117. 1904) seems to accept the views of Costantin. He also cites as exsiccati, Vestergren, Micr. rav. sel. 421.

ular branches, these last often arising at right angles and opposite, and (2) plectenchymatic strands; almost hyaline when young to cinnamon-brown in mature strands. Fertile hyphae arising irregularly from the large-celled mycelium or direct from cells of the strands, assurgent, simple or forked, with spore-bearing portion vesicular (spheroidal to ellipsoidal), often 20–28μ in length and 15–20μ in diameter. Spores finally arising also from undifferentiated hyphal and strand cells, hyaline, spheroidal to ovoidal, the spheroidal averaging 4.8–5.5μ in diameter, the ovoidal measuring 5–6$\times$6–8μ; extreme diameters, 3.2 and 9.8 μ. The conidial stage forms a continuous pulverulent, sometimes crust-like, area on the soil.

Hab. Hyphae on living roots of many plants and in soil, conidial stage on soil in the vicinity of diseased plants.

Specimens have been deposited in the herbaria of the Missouri Botanical Garden and the Bureau of Plant Industry, Washington, and in the collection of Professor W. G. Farlow, Cambridge.

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CABBAGE YELLOWS AND THE RELATION OF TEMPERATURE TO ITS OCCURRENCE

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Introduction

In recent years the diseases of plants caused by fungi belonging to the genus *Fusarium* have assumed greater and greater importance from an economic standpoint. A large amount of work has been done on the descriptions of such diseases on new hosts, and on the taxonomy of the genus *Fusarium,* but there has been comparatively little study of the relations of these fungi to their hosts, especially of the conditions under which members of this genus may become harmful parasites. Therefore, any work which throws light on this point is of value scientifically, first, because the mode of attack and the other relations of the parasitic species of *Fusarium* are all very closely related and very similar in their nature, and second, because of the possibility of throwing light on the problem of immunity or resistance of plants to the attack of parasitic organisms. The latter point is of particular interest, since it will be recalled that, up to the present time, practically the only control of the diseases caused by fungi belonging to this genus, has been by the selection or development of strains of the host resistant to fungous attack.

While assisting in the work of the development of strains of cabbage resistant to yellows in Wisconsin, investigations were undertaken to find the cause of the disease and the relations between host and parasite. During these investigations the relation of temperature to the occurrence of this disease was found to be of utmost importance, and the principal part of the work was accordingly devoted to this side of the problem. Nevertheless, before taking up these observations and experiments in detail, the results of the investigations into the etiology and pathological anatomy of the disease should

be discussed, in order that the physiological relations between host and parasite may be understood more clearly. A brief resumé of the literature on cabbage yellows will show the state of our knowledge of this disease at the time these investigations were taken up.

History of the Disease

The disease was first reported by Smith ('99, '99[a]), as occurring in New York State in 1895. He found the trouble exceedingly severe, threatening "to put an end to the successful growing of cabbages in considerable districts." He considered that the disease was "due to a soil Fusarium" but made no inoculation experiments. Aside from this observation his only contribution to our knowledge of the disease was in relation to its persistence in the soil; the organism resisted drying in the laboratory for three and one-half years. Woods ('99) showed that the characteristic symptom, the yellowing, was due to the presence of an increased amount of an oxidizing enzyme, peroxidase, in the diseased leaf tissue. Norton and Symons ('07) reported the presence of the disease in Maryland, but performed no experimental work.

Harter ('09), of the Bureau of Plant Industry, made inoculations of sterile soil with pure cultures of a *Fusarium* isolated from the stems of diseased cabbage plants. He was able to produce the characteristic symptoms in plants grown in that soil. In one trial, 83 per cent of these inoculations were successful; in a second, he reported that a large percentage of the plants showed typical symptoms, but no exact figure was given. He also made the statement that the fungus was a vascular parasite and formed microconidia in the vessels of the living plant. In addition to this paper Harter ('12) has published merely a popular account of the disease. Manns ('11) reported the disease as prevalent and destructive in Ohio but limited his work to field observations of a general nature.

Jones ('13, '14, '14[a]) in a series of papers reported the development of strains of winter and "kraut" types of cabbage which are highly resistant to the attack of this disease. These strains were developed by means of selection of sound

plants from badly diseased fields. In his last paper he reported that in the resistant strain 100 per cent formed commercial heads, or a yield of 18.8 tons to the acre; on the other hand, in the commercial strain used as controls, only 46 per cent of the plants lived and 24.2 per cent headed, or a yield of 2 tons to the acre.

These results show that, as far as practice is concerned, the disease has been controlled, but much remains to be done on the other aspects of the problem of the relation of host and parasite. Before discussing these phases, however, a brief description of the disease will not be out of place.

Symptoms of the Disease

The first evidence of the disease in the greenhouse is found on very young seedlings, often just after the appearance of the first true leaf, and is characterized by a rapid wilting of the cotyledons and dying of the roots while the stem is still turgid and, to all external appearances, normal. If, however, the conditions are not favorable for the attack of the fungus so early in the life of the host, the characteristic symptom —the yellowing of the leaf, to which the disease owes the name of "yellows"—is found. This yellowing may invade the entire plant, in which case wilting and death rapidly follow, or it may be confined to merely one side of the plant or leaf. If this one-sided invasion occurs, the plant or leaf ceases growth on the diseased side, but the green portions continue their development, bringing about a curvature of the plant or leaf toward the diseased area. This type is most frequently found on plants grown in the seed-beds in infected soil. These one-sided plants are usually stunted with the leaves loosely attached to the stem, so that they fall at the touch. If transplanted into the field such plants may die immediately, or if conditions are favorable for their development, they may live all summer, becoming stunted individuals with the lower leaves dying and dropping off, leaving a tuft of living leaves at the tip of a bare stalk. When healthy seedlings are transplanted to diseased soil the same characteristics occur; some plants die immediately—first, however, losing their chlo-

rophyll—while others become one-sided and stunted, but live throughout the summer. The latter rarely form heads.

Causal Organism

TAXONOMY

Cabbage yellows is caused by a soil fungus belonging to the genus *Fusarium*. The organism was first described by Wollenweber ('13) who, basing his classification on the work of Appel and Wollenweber ('10), placed it in the section *Elegans* and named it *Fusarium conglutinans* Wollenw. The description given by this author is as follows:

> '*Fusarium conglutinans* n. sp. differs from *F. orthoceras* * * * * in the absence of a wine-red color on rice which is a striking character of typical species of the section Elegans. * * * * Vascular parasite, cause of wilt disease of *Brassica oleracea* var. *capitata* (proved by Erwin F. Smith, L. R. Jones, L. L. Harter) in the United States of America.'

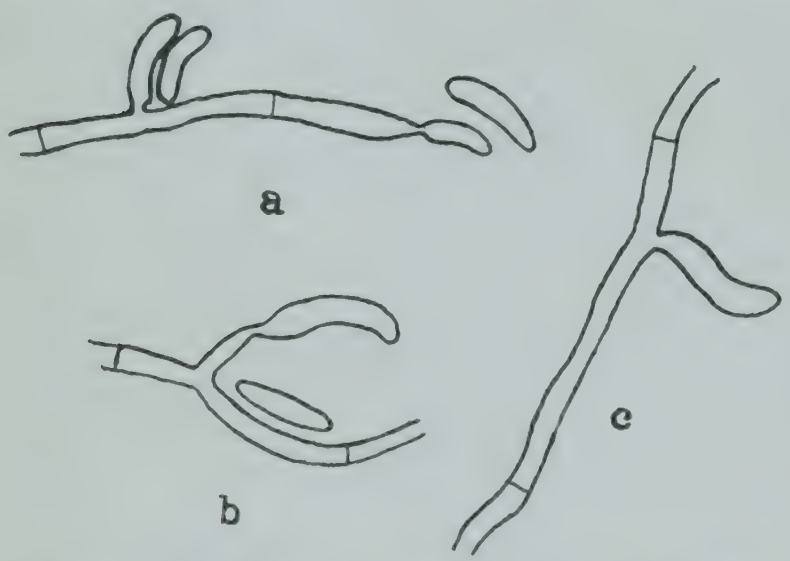

Fig. 1. Conidia production of *F. conglutinans* in Uschinsky's fluid after 48 hours: *a*, Culture V; *b*, Culture II; *c*, Culture I. Camera lucida sketch × 1000.

This description was based on a culture from the Laboratory of Plant Pathology of the University of Wisconsin. The same year Stevens ('13) ascribed the yellows to *Fusarium Brassicae* Thüm., citing Harter ('09) as his authority in spite of the following facts: first, that Harter specifically stated that he was working with an undescribed species and, second, that Wollenweber had included Harter's organism in his new species, *F. conglutinans*. Moreover, the organism that is parasitic on cabbage in the United States differs from *Fusarium Brassicae* Thüm. as described by De Thümen ('80)

in the following respects: *Fusarium Brassicae* forms *sporodochia,* while in *F. conglutinans* these are much reduced and usually not formed at all. *F. Brassicae* has conidia which are two-septate, while *F. conglutinans* has conidia, the majority of which are non-septate with a few one- and three-septate forms, two-septate spores not appearing. The main point of resemblance, from the description of *F. Brassicae,* is that the spore measurements fall within the same limits—a fact which, in view of the above differences, would scarcely suffice to put the two as synonymous.

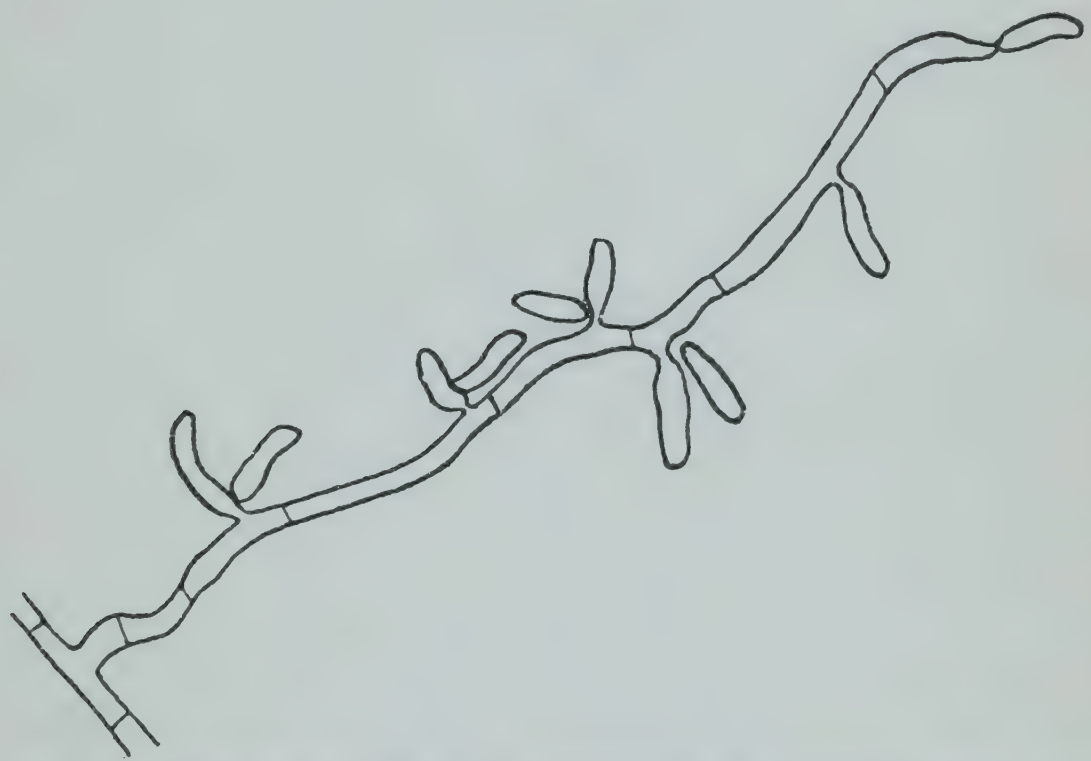

Fig. 2. Conidia production of *F. conglutinans* in Uschinsky's fluid after 48 hours. Culture I. Camera lucida sketch × 1000.

While the above description by Wollenweber is perhaps sufficient to differentiate *F. conglutinans* as a distinct form, it is hardly adequate as a diagnosis of the species; moreover, the question may be raised as to whether a physiological character, such as color production on a special medium, which has not been regarded as of specific rank in related genera, is sufficient basis for the establishment of a new species in the genus *Fusarium.* This, of course, introduces a new factor into the taxonomy of this genus, but the writer would hold it

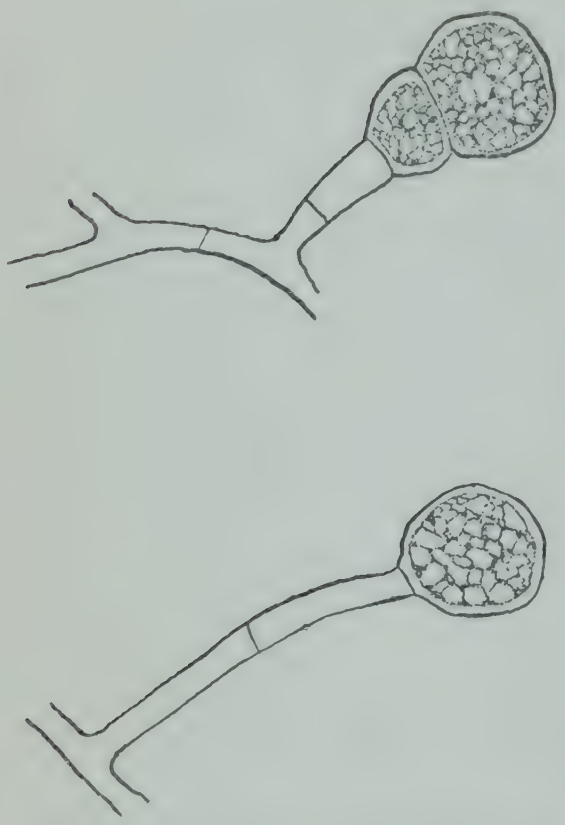

Fig. 3. Production of chlamydospores of *F. conglutinans* in Uschinsky's fluid after five days. Culture XI. Camera lucida sketch × 1000.

to be justifiable in such a group as the genus *Fusarium*, where a classification based on morphology alone has led and would continue to lead to confusion in many cases. That this character is constant in the case of *F. conglutinans*, there can be no doubt, but as additional evidence, some forty-three cultures of this organism have been maintained in the laboratory in connection with this work for a period of from six months to two years, and in no case did they produce red color on rice media, while cultures of *F. orthoceras*, carried as controls, did.

Moreover, on other media the organism maintained constant similarities with cultures from similar sources which on inoculation into the host produced the disease. The organisms were grown on potato hard agar, dextrose bouillon agar, soil extract agar, cooked potato plugs, cooked potato stems, and cooked rice. The mycelium in all cases grew well, giving a white fluffy growth at first, which gradually turned cream color, and in old cultures showed ochreous to brown strands in the aërial mycelium in the upper part of the tube. Spores of the "micro" type were found in all cultures in great abundance, especially during the early part of the growth of the cultures. The production of aërial mycelium was most abundant in those cases where the amount of carbohydrate in the substratum was greatest or most available.

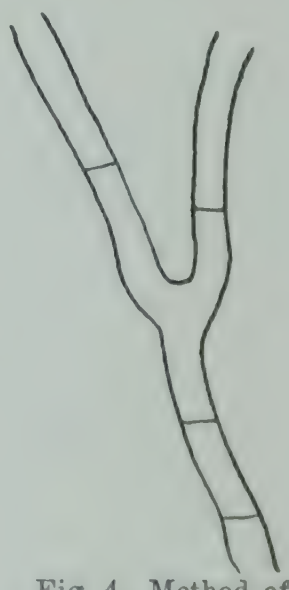

Fig. 4. Method of branching of mycelium of *F. conglutinans* in Uschinsky's fluid. Culture I. Camera lucida sketch × 1000.

After growth of a few weeks chlamydospores were found in most of the cultures, the microspores were beginning to become abnormal, and the few macrospores were also breaking down. The macrospores were found to be produced best on potato stems, next best on the potato agar, while very few appeared on cooked potato plugs and cooked rice.

Besides the tube cultures, hanging-drop cultures in a modified Uschinsky's fluid[1] were observed. In this medium the fungus produced microspores abundantly in cultures only two days old when kept at room temperatures. Chlamydospores were found to begin to form in cultures but five days old, although they did not mature in so short a time. Usually the first chlamydospores occurred terminally; later other parts of the mycelium rounded up to form the intercalary spores.

A revised description of the fungus is as follows:

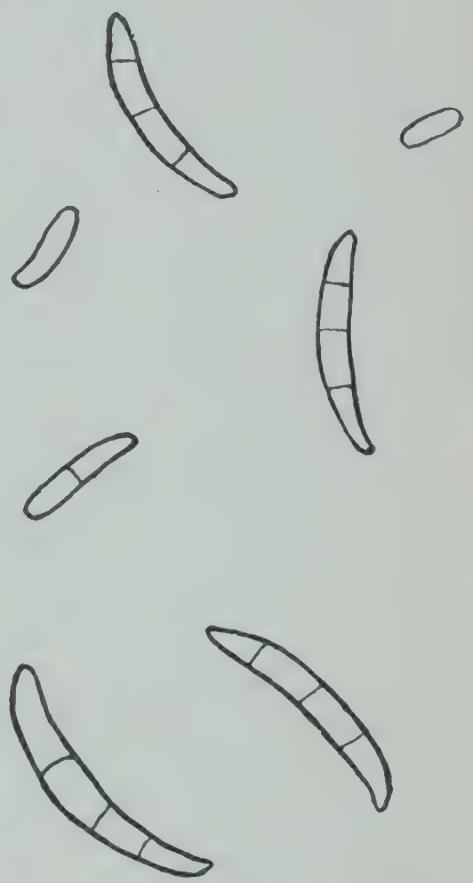

Fig. 5. Conidia of *F. conglutinans*. Culture LVI on potato stem. Camera lucida sketch × 800.

Fusarium conglutinans Wollenw.

Sporodochia lacking or greatly reduced; pionnotes never present. Conidia borne on short conidiophores strewn throughout the mycelium, majority non-septate, a few one-septate and three-septate. The non-septate conidia ovoid to ellipsoidal, hyaline, 2.5–4 × 6–15μ, the majority being 2.5–3 × 7–10μ. One-septate conidia hyaline, cylindrical, with

[1] This medium was a modification of the standard Uschinsky's fluid, and was made up as follows:

Water, distilled	1000 grams	Magnesium sulphate	0.3 grams
Glycerin	30 grams	Dipotassium phosphate ..	2 grams
Sodium chloride	5 grams	Ammonium tartrate	6 grams
Calcium chloride	0.1 grams	Sodium asparaginate	3 grams

The solution was sterilized at ten pounds pressure for twenty minutes in the autoclave.

rounded ends, long axis slightly bent, dimensions $4 \times 19\mu$. Three-septate conidia fusiform, hyaline, with both end-cells tapering and with rounded tips, no sharply differentiated foot, dimensions $3.5–5.5 \times 25–33\mu$. Conidia with higher septation very rare.

In culture aërial mycelium white at first, becoming cream-colored and finally showing a development of ochreous strands of thallo-plectenchymatic tissue throughout, but no sclerotia. Grows well on potato agar, dextrose bouillon agar, Uschinsky's fluid, cooked rice, cooked potato plugs, and potato stems. On no medium is there any color production except the slight yellowing spoken of above. In older cultures terminal or intercalary chlamydospores are produced. They are usually one-, sometimes two-celled, spherical to ovoid with a thick irregular wall, frequently slightly colored. Dimensions $7–12 \times 7–15\mu$.

The fungus is found in the soil and is a vascular parasite attacking cabbage, *Brassica oleracea* var. *capitata,* causing the yellows, or wilt disease. It has also been isolated as a saprophyte from China aster and tubers of potato (Lewis, '13).[1]

TEMPERATURE STUDIES

In view of the later work in regard to the relation of temperature to the occurrence of the disease, it will be well to discuss briefly this relation for the fungus in pure culture, both as to growth and germination of conidia. The latter will be considered first.

In order to obtain spores of the fungus free from pieces of mycelium, a bit of mycelium was placed in a hanging-drop of Uschinsky's fluid in a Van Tieghem cell which was partially filled with Uschinsky's fluid below. The spores were formed abundantly at room temperatures in forty-eight hours and allowed to drop into the lower liquid from which they were

[1] Through the kindness of Dr. W. J. Morse, of the Maine Agricultural Experiment Station, transfers of these two strains of *Fusarium conglutinans* were obtained, and inoculations made on February 2, 1915, on five plants each, and again on February 26, 1915, with the strain from aster on ten plants; both gave negative results. This would indicate that they belonged to a saprophytic strain, although the results might be due to the fact that the fungi had been so long in culture that they had lost their virulence, or to the small number of trials made. Control cultures of this fungus from cabbage, however, gave 80 per cent infection in the first case and 100 per cent in the second trial.

transferred to other Van Tieghem cells by means of a sterile pipette. They were immediately placed in the incubators at the desired temperatures, and observed at intervals for germination. All observations were made in duplicate, and the trials were repeated twice to verify them. The temperatures used were 8–10°C., 10–12°C., 16°C., 21°C., and 33°C. The results are brought together in table 1.

TABLE I

GERMINATION OF CONIDIA OF FUSARIUM CONGLUTINANS AT VARIOUS TEMPERATURES

Hours of exposure	Germination (+) at the following temperatures									
	8–10° C.		10–12° C.		16° C.		21° C.		33° C.	
	Trial no.		Trial no.		Trial no.		Trial no.		Trial no.	
	1	2	1	2	1	2	1	2	1	2
1	—	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—	+	+
6	—	—	—	—	—	—	—	—	+	+
8	—	—	—	—	+*	+*	+	+	+	+
12	—	—	—	—	+	+	+	+	+	+
24	—	—	—	—	+	+	+	+	+	+
36	—	—	—†	—†	+	+	+	+	+	+
72	—	—	—	—	+	+	+	+	+	+

* In a later test in which more frequent observations were made, conidia at this temperature (16°C.) germinated 12 hours after the beginning of the exposure.

† At this temperature (10–12° C.) spores were found to germinate after 36 hours in a later experiment. The number that germinated, however, was very small and the growth exceedingly slow.

It will be noted that, as was to be expected, spores of the fungus germinated best at the higher temperatures of the experiment, although they were able to grow slowly at the lower temperatures. These facts are further borne out by the growth of the fungus on potato agar. Transfers of a bit of the mycelium from a rapidly growing culture were placed in the center of plates of potato hard agar, and the plates were then placed in the incubators at the desired temperatures.

Three plates were carried at each temperature, and measurements of the growth of the colonies of the mycelium were made each day for ten days, after which time the experiment was discontinued because of the contamination of some of the plates and the drying out of others. The results are given in table II.

TABLE II

GROWTH OF FUSARIUM CONGLUTINANS AT VARIOUS TEMPERATURES

Age of colony in days	Diameter of colony in cm. at various temperatures											
	4–8° C.			18° C.			21–22° C.			25° C.		
	Plate no.			Plate no.			Plate no.			Plate no.		
	1	2	3	1	2	3	1	2	3	1	2	3
1	....	....	....	....	....	....	0.9	0.9	0.6	0.7	1.1	0.1
2	....	....	....	0.1	0.1	0.1	1.6	1.5	1.2	1.8	2.0	1.1
3	0.1	0.1	0.1	0.6	0.6	0.6	2.0	2.0	1.8	2.0	2.2	1.7
4	0.2	0.2	0.1	1.0	0.9	0.9	3.0	2.8	2.4	2.9	3.2	2.9
5	0.4	0.5	0.4	1.2	1.1	1.2	3.6	3.4	3.0	3.4	—*	3.1
6	0.5	0.7	0.5	1.4	1.2	1.3	4.0	3.8	3.4	3.8	....	3.7
7	0.7	0.8	0.9	1.5	1.3	1.5	4.5	4.3	—*	4.6	....	4.4
8	1.1	1.1	1.1	1.9	1.7	1.7	5.1	4.9	....	5.1	....	5.3
9	1.4	1.5	1.3	2.0	1.8	1.8	5.5	5.4	....	5.6	....	6.0
10	1.6	1.7	1.4	2.2	2.2	1.9	6.2	6.0	....	—*	....	6.6
Average growth per day	0.16	0.17	0.14	0.22	0.22	0.19	0.62	0.60	0.56	0.62	0.80	0.66
Average for each series	0.16			0.21			0.59			0.69		

*Contaminated.

If the growth of *Fusarium conglutinans* be compared with that of some of our more common saprophytic forms as, for example, *Penicillium glaucum*, or *Aspergillus niger*, as reported in the literature, it will be noted that, while the optimum of these forms is also high, they can grow better than *F. conglutinans* at the lower temperatures. In other respects the curves of growth of these forms would approximate one another very closely.

No attempt was made to find the maximum and minimum growth temperature for this fungus, because the object of the work was to find, if possible, an explanation for the fact that yellows occurred in the host at high temperatures rather than at low. This relation will be discussed later when a full review of the points involved will be taken up.

Inoculation Experiments

The first inoculation experiments were tried during the summer of 1912. On July 17 five flats of soil were planted to cabbage; three contained soil brought from the experimental plot at Racine and two, normal greenhouse soil. One of the latter was left as a control, and the other was inoculated with spores from a pure culture of the fungus. These flats were kept shaded on the north side of some shrubbery in the pathological garden and no typical yellows had appeared by September 7, when they were discarded. On August 23 five plants in the pathological garden were inoculated by placing mycelium of a rapidly growing culture in contact with the roots. No disease was found up to October 22, when frost killed the plants. The seedlings were two weeks old at the time of inoculation. Again, on September 10, thirty healthy plants were transferred to three flats of soil brought from the experimental plots at Racine, but no disease was found in any of the flats by December 2.

On January 6, 1913, twelve pots of sterile soil were planted to cabbage and inoculated by stirring cultures of *Fusarium* into the pots. Twelve pots of diseased soil from the experimental plot, eight of sterilized soil, and four of normal undiseased soil were planted as controls. Spores were abundant in all the cultures used. No yellows had appeared by April 29, and the plants were then pulled and the pots replanted. Instead of keeping this second lot in the open greenhouse,

however, they were placed under a glass, such as is used in a forcing-bed, thereby giving a higher temperature than could be attained in the open house. On January 14 the plants in one pot of inoculated soil showed the characteristic symptoms, and on July 10 the plants in a second pot had succumbed. On July 12 a third pot contained plants showing the disease. Damping off due to *Rhizoctonia* interfered with the value of this trial. The diseased plants were plated out on potato hard agar in all cases, and the typical *Fusarium* found to be present. As will be noted, it was only after the temperature of the pots had been raised that there was any occurrence of the disease. Curves showing the temperature attained by placing the plants under the glass are given in fig. 6.

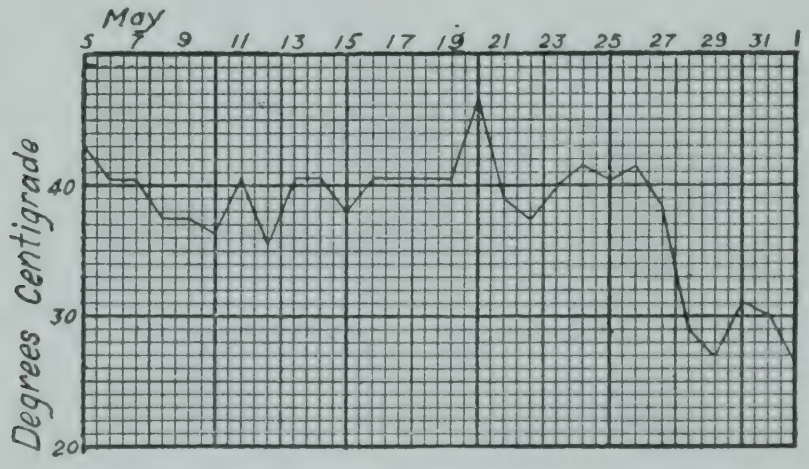

Fig. 6. Diagram showing temperature under glass in greenhouse during inoculation experiments, May 5–31, 1914.

On May 10, 1913, another inoculation experiment was started with seedlings grown in normal greenhouse soil. The plants used were about ten days old — just showing the first true leaf. Five pots of soil were used, five seedlings in each pot. Pot 1 was left as a control, while the roots of the plants in the other pots were dipped into a suspension of spores from a pure culture and immediately planted. On May 13 they had all recovered from the effects of transplanting and were in good

condition. On July 10 symptoms of yellows showed in pots 4 and 5; on July 14 the plants in pot 3 became diseased, but no disease was found in pots 1 or 2. The plants were plated on potato hard agar, and *F. conglutinans* was recovered from plants from pots 3, 4, and 5. None was found on seedlings plated from pots 1 and 2. Culture V, which upon reinoculation again produced the disease, was one of these cultures (table v).

On May 27, 1913, a more extensive inoculation experiment was started; part of the pots containing the plants were placed in the greenhouse and part in the pathological garden. As the greenhouse was not heated, the difference of conditions was not noticeable, and, therefore, the results are combined. For this trial twenty pots were planted to cabbage. These pots were in duplicate, ten being placed in the greenhouse and ten in the soil of the garden. The treatment of the soil in these pots was as follows: Eight pots contained soil from the experimental plots at Racine, and eight others normal greenhouse soil. These sixteen containers were sterilized in an autoclave at eleven pounds pressure for four hours. Four of each of them were used as controls, four were inoculated with pure cultures of *F. conglutinans,* and the remaining four were inoculated with wilted leaves of the diseased plants. Two pots of normal greenhouse soil and two of normal diseased soil were added to the series as controls. The cultures were added by mixing them with the surface soil in the pots. The seed used were not good, and, therefore, the plants did not come up well, so that in the following pots there were no plants: one pot of diseased soil sterilized but not inoculated; two pots of diseased soil sterilized and inoculated with pure cultures; two of diseased soil sterilized and inoculated with the leaves; one pot of normal greenhouse soil not inoculated; and one of sterilized greenhouse soil inoculated with leaves. The results of this experiment are given in table III.

TABLE III

RESULTS OF INOCULATIONS WITH PURE CULTURES OF FUSARIUM CONGLUTINANS

Pot no.	Kind of soil	Treatment of soil	Plants per pot		
			Total no.	No. diseased	Percentage diseased
1	Infected	Sterilized	7	0	0
2	Infected	Sterilized	0	.....	.....
3	Infected	Ster'z'd and inoc'l'd	4	3	75
4	Infected	Ster'z'd and inoc'l'd	1	1	100
5	Infected	Normal	5	4	80
6	Infected	Normal	6	6	100
7	Uninfected	Normal	1	0	0
8	Uninfected	Normal	0	.....	.....
9	Uninfected	Ster'z'd and inoc'l'd	3	1	33
10	Uninfected	Ster'z'd and inoc'l'd	5	5	100
11	Uninfected	Ster'z'd and inoc'l'd	1	1	100
12	Uninfected	Ster'z'd and inoc'l'd	2	1	50
13	Uninfected	Sterilized	6	0	0
14	Uninfected	Sterilized	4	0	0
15	Uninfected	Ster'z'd and infect. leaves	2	1	50
16	Uninfected	Ster'z'd and infect. leaves	0	.....	.....

The results are not as conclusive as they might be, however, as the number of plants used was very small due to the poor seed mentioned above. The pots in which no plants grew in either of the duplicates were omitted. An idea of the appearance of the plants at the time of making counts may be had from pl. 1, fig. 2. It should be noted that these successful inoculations were made at the warmest time in the summer. Plates were made on July 14 from plants in each pot, and in all cases the diseased seedlings gave pure cultures of *F. conglutinans,* while those from the controls remained sterile. Culture X was one of these and upon reinoculation again produced the disease (table v).

On June 12 the above experiment was repeated, using three flats of soil (from the experimental field), two of which had been sterilized at eleven pounds pressure for four hours on two successive days, the other remaining untreated. One of

the sterile flats was inoculated by stirring into its surface ten pure cultures of *F. conglutinans* which were sporulating abundantly. Then all the flats were planted. As an additional control, a flat of normal greenhouse soil was placed in the series. On July 7 yellows began to appear in the sterilized inoculated flat and continued to spread until July 16, when the experiment was concluded by making plates from the plants from the sterilized inoculated, and the sterilized flats. *F. conglutinans* was found as the cause of the yellowing in all the plants, while the control plants remained sterile. This is shown well in pl. 2, figs. 15 and 16. Exact counts were not made.

Again, on June 29, four pots of sterile greenhouse soil were inoculated with cultures of *F. conglutinans,* and on July 24 yellows was found in all four of the pots. On July 11 inoculations of individual plants were repeated by dipping wounded plant roots into suspensions of the spores of the fungus in sterile water. Adequate controls were included in this series and in all cases the control plants remained healthy, while among the inoculated plants, 50 per cent of the individuals showed the characteristic symptoms on July 24, when the experiment was discontinued.

VIRULENCE OF CULTURES

Pure cultures of *F. conglutinans* vary greatly in their virulence, and the cause of this variation is not certain. From inoculation experiments it would seem that, in general, the longer the organism has been carried in culture the greater is the probability that it has lost its virulence. On the other hand, drying in culture seems to have little or no ill effect on the virulence of the organism.

The susceptibility of the host must also be considered as an important factor when the fungus-host relation hangs in such a delicate balance, and the source of the culture is always

of importance also. The medium upon which the culture is grown and the state of the mycelium and spores have been pointed out by Wollenweber as important factors in other species of *Fusarium* which produce plant disease, and doubtless they bear their part in the irregularity of the results presented here.

In a series of inoculation experiments made at the Missouri Botanical Garden, recently isolated cultures were used as sources of infection. The cultures were grown on cooked potato stems, and inoculation was effected by placing a bit of the culture tissue in contact with a wound on the hypocotyl of the plant. The plants were in the cotyledonous stage, and after inoculation were placed in normal uninfected greenhouse soil. Five seedlings were placed in each pot. Table IV gives the results of the experiments.

TABLE IV

PRELIMINARY STUDY OF VARIATION OF VIRULENCE OF FUSARIUM CONGLUTINANS IN PURE CULTURE

Culture number	Date of isolation	Total no. of plants	No. of diseased plants	Per cent of diseased plants
XVI	7/14/13	40	30	75.0
LV	11/17/14	15	13	86.6
LVI	2/1/15	5	5	100.0
Control	.....	10	0	0.0

It will be noted that where the larger number of plants was used the percentage of infection fell. This result might have been expected if the age of the cultures used and the great variation in susceptibility of the host plant were taken into consideration, but to gather more data on these points a trial was made with a large series of cultures that had been isolated at various times and also from various sources.

Table V gives the data on the inoculation experiment which was carried out similarly to the one just reported.

TABLE V
RESULT OF INOCULATION EXPERIMENT SHOWING VARIATIONS IN VIRULENCE OF FUSARIUM CONGLUTINANS IN PURE CULTURE

Culture number	Species	Source	Date of isolation	Pathogenicity					
				Damped off		Yellowed		Healthy	
				No.	Per cent	No.	Per cent	No.	Per cent
I	*F. conglutinans*	Cabbage	5/16/13	0	0	0	0	5	100
II	*F. conglutinans*	Cabbage	6/12/13	0	0	0	0	5	100
V	*F. conglutinans*	Cabbage	5/10/13	1	20	3	60	1	20
VI	*F. conglutinans*	Cabbage	5/10/13	1	20	0	0	4	80
IX	*F. conglutinans*	Cabbage	7/14/13	0	0	0	0	5	100
X	*F. conglutinans*	Cabbage	7/14/13	1	20	1	20	3	60
XI	*F. conglutinans*	Cabbage	7/14/13	5	100	0	0	0	0
XIII	*F. conglutinans*	Cabbage	7/14/13	0	0	2	40	3	60
XIV	*F. conglutinans*	Cabbage	7/14/13	0	0	0	0	5	100
XVI	*F. conglutinans*	Cabbage	7/14/13	0	0	4	80	1	20
XVII	*F. conglutinans*	Cabbage	7/28/13	0	0	0	0	5	100
XVIII	Undetermined	Cauliflower	7/26/13	0	0	0	0	5	100
XIX	*F. conglutinans*	Cabbage	5/ 6/13	0	0	3	60	2	40
XX	*F. conglutinans*	Cauliflower	7/26/13	0	0	2	40	3	60
XXI	*F. conglutinans*	Cabbage	7/26/13	0	0	0	0	5	100
XXII	*F. conglutinans*	Cabbage	7/26/13	0	0	0	0	5	100
XXIII	*F. conglutinans*	Cabbage	7/26/13	0	0	0	0	5	100
XXIV	*F. conglutinans*	Cabbage	7/26/13	0	0	0	0	5	100
XXV	*F. conglutinans*	Cabbage	7/27/13	4	80	1	20	0	0
XXVI	*F. orthoceras*	Cabbage	5/ 6/13	0	0	0	0	5	100
XXVII	Undetermined	Cabbage	8/ 4/12	0	0	0	0	5	100
XXVIII	*F. conglutinans*	Cabbage	8/ 4/12	0	0	0	0	5	100
XXIX	Undetermined	Cauliflower	8/24/12	0	0	0	0	5	100
XXX	*F. conglutinans*	Cabbage	6/28/12	0	0	3	60	2	40
XXXII	*F. conglutinans*	Cabbage	6/28/12	1	20	4	80	0	0
XXXIII	Undetermined	Cabbage	6/28/12	2	40	0	0	3	60
XXXV	*F. conglutinans*	Cabbage	8/24/12	1	20	0	0	4	80
XXXVI	*F. conglutinans*	Cabbage	6/24/12	2	40	0	0	3	60
XXXVII	*F. conglutinans*	Cabbage	6/28/12	1	20	1	20	3	60
XXXVIII	*F. conglutinans*	Cabbage	6/28/13	0	0	0	0	5	100
XXXIX	*F. conglutinans*	Cabbage	6/28/13	1	20	0	0	4	80
XL	*F. conglutinans*	Cauliflower	1/ 3/14	5	100	0	0	0	0
XLII	*F. conglutinans*	Cabbage	2/14/14	2	40	2	40	1	20
XLIII	Undetermined	Aster	.....	1	20	0	0	4	80
XLIV	*F. conglutinans*	Aster*	.....	0	0	0	0	5	100
XLV	*F. conglutinans*	Potato*	.....	3	60	0	0	2	40
XLVI	*F. conglutinans*	Cabbage	4/13/14	1	20	0	0	4	80
XLVII	*F. conglutinans*	Cabbage	3/12/14	0	0	3	60	2	40
LI	*F. conglutinans*	Cabbage	5/ 6/14	0	0	0	0	5	100
LII	*F. conglutinans*	Cabbage	5/ 6/14	0	0	2	40	3	60
LIII	*F. conglutinans*	Cabbage	5/18/14	0	0	2	40	3	60
LIV	Undetermined	Cabbage	9/24/14	0	0	0	0	5	100
LV	*F. conglutinans*	Cabbage	11/17/14	0	0	4	80	1	20
LVI	*F. conglutinans*	Cabbage	2/ 1/15	0	0	5	100	0	0
Control	No fungus	.....	.....	1	10	0	0	9	90

*Isolated by Lewis ('13) at the Maine Agricultural Experiment Station and determined by H. W. Wollenweber, Bureau of Plant Industry, Washington, D. C.

The cultures were all prepared in the same way for the experiment. They were all grown on cooked potato stems, and were of the same age. Each culture was used to inoculate five plants by inserting a bit of the mycelium into the hypocotyl of young seedlings still in the cotyledonous stage.

The previous history of the cultures, of course, differed for the individual. Cultures VI, XVII, and XIX had been allowed to dry out on potato hard agar for fourteen months, that is, from July 14, 1913, to September 26, 1914, and then were transferred to cooked potato stems. On January 12, 1915, they were again transferred to fresh cooked potato stems, and these cultures were used in the experiment. Although two of them (VI and XVII) apparently lost their virulence, the third (XIX) retained its ability to attack the host even after this severe drying. Other strains which had not been allowed to dry out but which were kept on fresh media, possessed no greater virulence, nor did any greater percentage of them exhibit pathogenicity.

The length of time the organism has been in culture seems to be a more important factor; for cultures isolated late in 1914 showed proportionally a larger number virulent than did those isolated at earlier dates. In addition, the more recent isolations showed the greater virulence. That this is not invariable, however, is shown by the fact that many of the cultures first isolated still retained their virulence, viz., XXX, XXXII, XXXVII, all three of which were isolated on June 28, 1912.

The source of the culture seems to have greater influence. Of the six strains of *F. conglutinans* isolated from cauliflower grown in diseased soil and apparently attacked with yellows, but one (XX) showed any ability to infect cabbage and that only to a limited extent. Strains from aster and potato, kindly furnished by Dr. W. J. Morse of the Maine Agricultural Experiment Station, also gave negative results when inoculated into cabbage. *F. orthoceras,* which had been isolated from the stem of a diseased cabbage plant, was introduced into the series as a control. A number of undetermined Fusarium cultures which had been isolated from cabbage, cauli-

flower, and China aster were added for the same reason. None of these latter were capable of infecting the living cabbage plant.

SUSCEPTIBILITY OF HOST

That the susceptibility of the host plant must also play an important part in this question of inoculation is shown by the fact that so few of the cultures gave a perfect (100 per cent) infection, although the inoculations were made with parts of the same culture on plants from the same pot and under as identical conditions as possible.

Further evidence on this point was also shown when the difference in the length of the incubation period of any one culture was noted on plants of the same variety and age. For example, in the last experiment observations were made daily in the greenhouse, and the condition of the plants noted. The results of these observations are brought together for a few of the cultures in table VI.

TABLE VI

RESULTS OF OBSERVATIONS ON INDIVIDUAL SUSCEPTIBILITY AS SHOWN BY THE INCUBATION PERIOD UPON INOCULATION

Culture no.	Number of diseased plants in each pot at the various days of incubation						
	15	16	17	19	23	40	50
XVI	1	2	3	3	3	3	4
V	.....	2	2	2	3	3	3
XIX	.....	.....	2	3	3	3	3
XLII	.....	.....	1	1	4	4	4
XXX	.....	.....	.....	2	3	3	3
XXXII	.....	.....	.....	1	2	3	4
Control	.....	.....	.....	.....	.....	.....	.....

Thus it is shown that not only were some virulent cultures slower in taking effect than others, but that the individual plants were markedly different in their ability to resist the fungus. Although what constitutes such resistance has not been worked out, a little evidence gathered during these investigations may well be presented here.

In the field it was noted that the plants of the resistant strains of cabbage were, as a rule, larger than plants of the commercial strains of the same age. The first year it was thought that this difference in size might be due to crowding in the seed-bed of the plants of the commercial strain, chiefly because the amount of available seed of the resistant varieties was limited, while that of the commercial strain was plentiful. When this fact repeated itself over three years, experiments in the laboratory were run to account for the difference. Seeds were placed between moist filter paper in petri dishes and allowed to germinate. Twenty-five seeds were placed in each dish, and two dishes of each strain, VIII a-16 and commercial Danish Ball-head, were germinated. After wetting up the filter paper with distilled water the dishes were all placed in an incubator at 22°C. The seeds of the resistant strain germinated twelve hours before those of the commercial varieties, three days after the beginning of the experiment. Plate 2, figs. 5 and 6 give an idea of the appearance of the seedlings at this time, under similar conditions of moisture and temperature.

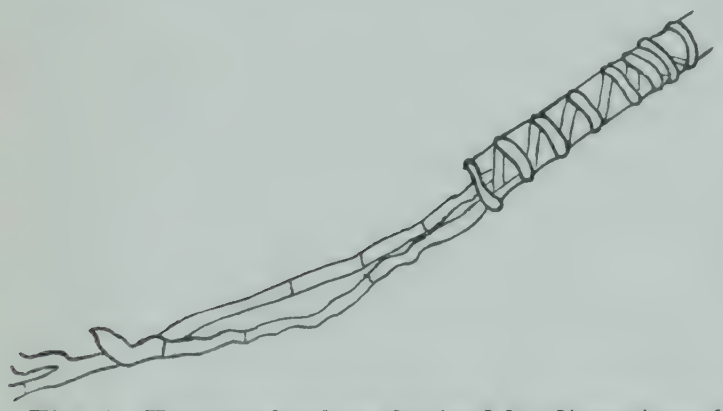

Fig. 7. Fungous hyphae obtained by dissection of diseased stem after boiling in KOH solution. Camera lucida sketch.

This characteristic of growth suggested that there might be a considerable difference in osmotic pressure between the root cells of the two strains, and experimental work was undertaken to determine whether the threshold of plasmolysis of the two strands differed toward NaCl solution as a plasmolytic agent. Two trials were made using the root-hairs as indicators, but in neither case was any difference between the threshold of plasmolysis of the resistant strain and that of the susceptible strain found.

Host Relations

MORPHOLOGY

The distribution of the fungus in the living host tissues is limited to the vascular bundles. This fact was first shown in making plates from old stems of diseased plants. The stems were cut cross-wise in thin sections and, after sterilization in hydrogen peroxide for five minutes and washing in sterile water, were laid on the surface of poured plates of potato hard agar. Invariably the first growth of the mycelium appeared from the fibro-vascular ring (pl. 2, fig. 14). Upon dissection of diseased seedlings the hyphae were demonstrable

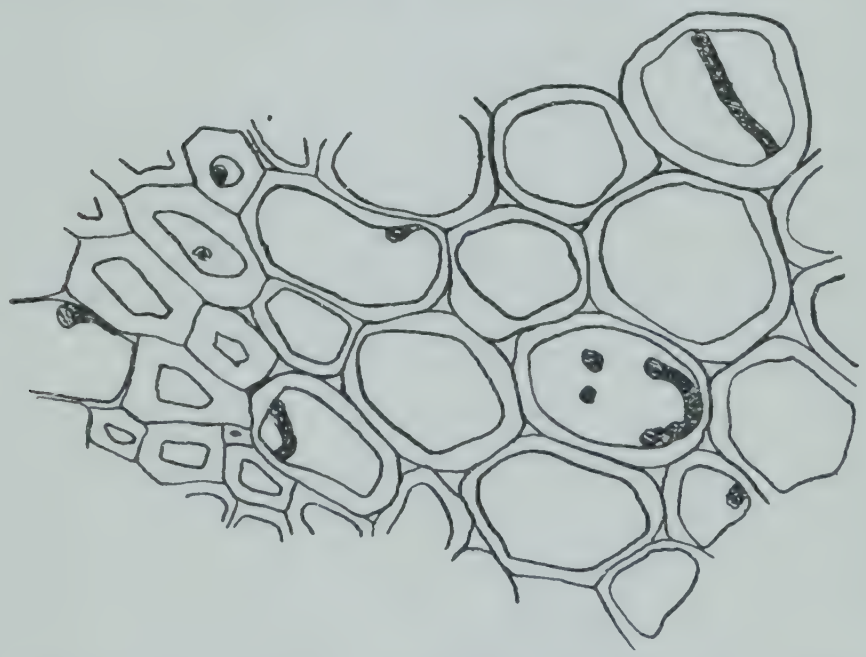

Fig. 8. Cross-section of vascular bundle from diseased cabbage stem, showing distribution of fungus in vessels. Note preponderance of cut ends of hyphae. Stained with Pianeze IIIb. Camera lucida sketch × 1000.

traversing the lumina of the bundles longitudinally. The stems were first boiled for five minutes in a 5 per cent potassium hydroxide solution and then dissected under a hand lens. The final examination was made under the compound microscope. In no case was a very large amount of mycelium found in any single vessel (fig. 7).

In later work the diseased stems were imbedded in paraffin in the usual manner, after fixing in Gilson's solution, and stained with Pianeze IIIb, as recommended by Vaughan ('14). The fungus stained a deep red, while the host tissue was col-

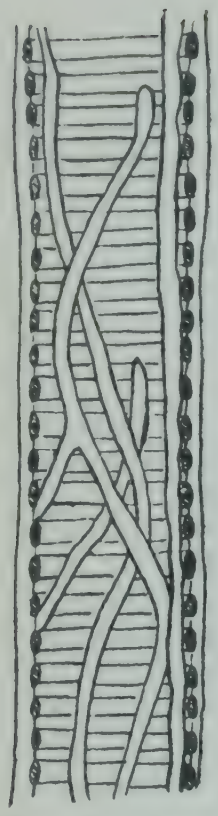

Fig. 9. Longitudinal section of vessel in diseased cabbage stem, showing vegetative hyphae. Stained with Pianeze IIIb. Camera lucida sketch × 1000.

ored green. Longitudinal sections showed the hyphae of the fungus running longitudinally in the lumina of the spiral vessels and the bast fibres. Cross-sections showed only the cut ends of the fungus. Drawings illustrating these facts are shown in figs. 8 and 9 which were made with the aid of a camera lucida. It was found that besides the purely vegetative hyphae, the fungus produced conidia in the vessels of the host (fig. 10). Those spores observed in the host tissue were all of the unicellular type.

All the evidence shows that the fungus attacks the root first, but just how remains to be worked out. After entering the host, it is confined to the vascular system. The fungus was never isolated from the stem until after a marked yellowing of the leaves appeared, although it was always present in the tissues before they had been killed. This fact is brought out in pl. 2, fig. 12 in which is shown a branched plant, one branch of which was attacked, while the other remained healthy in appearance. The leaf at *E* was still alive although one side of it was yellow. The stem of the plant appeared normal externally. The fungus, however, was isolated from the stem below the branching and at the points *D* and *E* on the diseased branch, while the parts at *B* and *C* on the other branch remained sterile. The plate made from this plant is shown in pl. 2, fig. 13.

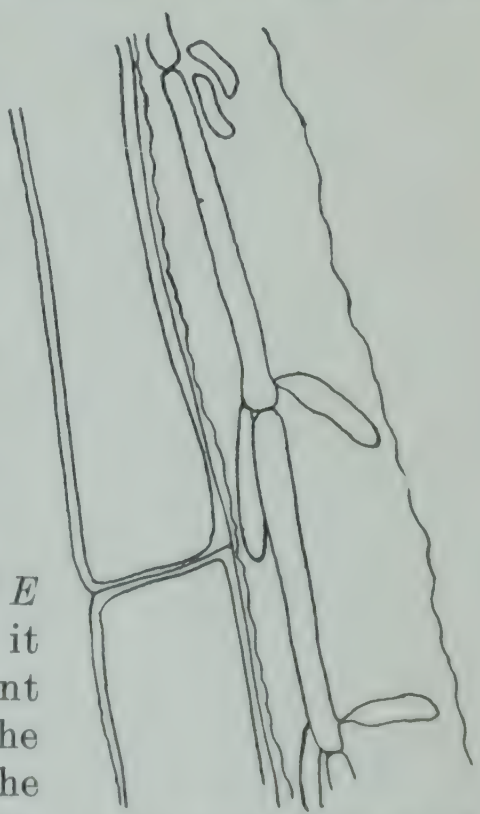

Fig. 10. Longitudinal section of vessel in diseased cabbage stem, showing production of conidia. Stained with Pianeze IIIb. Camera lucida sketch × 1000.

After the death of the host the fungus traverses all the tissues, sporulating at the surface and within the host also. In this way the fungus is able to return to the soil. Whether it may winter over in the host tissue was tested by marking plants which have been killed by the yellows in the field in 1913, and then bringing these plants into the laboratory in the spring of 1914. The stumps were first freed from the soil by brushing them under water and then washing in running water for fifteen minutes. After this washing the stalks were divided into equal portions and placed in two flats of sterile greenhouse soil (sterilized in the autoclave at eleven pounds pressure for five hours) and left for twenty-four days, after which time the flats were planted to cabbage on June 3, 1914. Yellows was found in both flats on July 6, 1914, showing that the fungus was able to get back into the soil from these stems, or that the roots coming in contact with the stems were attacked.

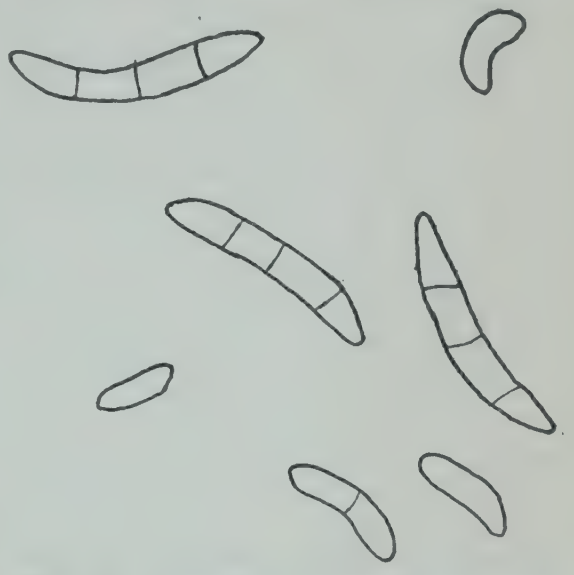

Fig. 11. Conidia obtained from overwintered cabbage stem in spring of 1915. Camera lucida sketch × 800.

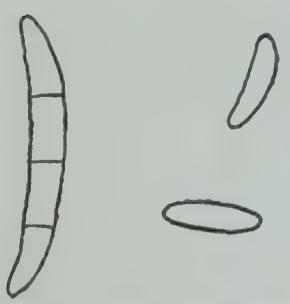

Fig. 12. Conidia obtained from a second stem of over-wintered cabbage. Camera lucida sketch × 800.

That the fungus may live over in the soil was first shown by E. F. Smith ('99, '99[a]), when he found that the organism in the soil was able to withstand drying in the laboratory for three and one-half years. Dr. M. P. Henderson in some unpublished studies on *Phoma lingam* showed inadvertently that the stumps of cabbage are not necessary for the transmission of *Fusarium conglutinans*, as it is able to live in the soil. He found that *F. conglutinans* was still present and virulent in soil that had been sifted through a fine sieve.

This experiment was repeated with soil from the experimental field at Racine. The soil was sifted through a 40-mesh sieve and in this earth cabbage was then planted. All the plants were found diseased at the end of fourteen days, while the plants in a control pot of uninfected soil remained healthy. Plants in a pot of infected soil, unsieved, showed the disease slightly earlier, at the end of twelve days, this difference in time being due probably to the fact that in the sieved soil the organism existed only as spores and, therefore, took longer to infect than where it grew rapidly from mycelium in the old host tissue.

TEMPERATURE

Literature.—Before discussing the significance of the temperature relation in the case of the attack of *F. conglutinans* on cabbage, the results obtained in other diseases where temperature has proven of pathological importance should be considered briefly for comparison.

Upon making a careful review of the literature it was found that our knowledge of this field is very limited and fragmentary, although the importance of temperature is generally recognized. Earle ('02), in a paper on the environmental factors concerned with disease, discussed the temperature relations in a general way, pointing out that for health, the plant must have temperatures of the proper degree for growth. Duggar ('09) also recognized the importance of temperature in relation to the susceptibility of the host to fungous attack, but in a paper of this nature he could make nothing more than a general statement. Reed ('10) in a similar paper paid more attention to this one of the many environmental factors involved, and showed that the temperature most favorable for the attack of a fungus is dependent entirely on the particular organism under consideration. He cited as examples of this relation the bitter rot of apple which is favored by high temperatures and the leaf curl of the peach which thrives best under cool weather conditions. Klebahn ('12, p. 88) stated that, although the temperature is undoubt-

edly an important factor in the case of diseases caused by the fungi, there has been insufficient work on the question to warrant more than a general discussion of the subject.

In spite of this lack of correlated facts on the relation of temperature to plant disease, there are many isolated notes scattered through plant pathological literature, and an attempt has been made to bring them together at this time. In order to put them in the best shape for comparison, one with another, it was thought well to arrange them according to the natural grouping of the parasites upon which the observations were made.

Schizomycetes.—The diseases caused by bacteria may be placed first. Halsted ('98) pointed out that the summer of 1894, which was excessively hot in New Jersey, was characterized by an outbreak of fire blight due to *Bacillus amylovorus.* Whetzel ('06), from evidence in New York, confirmed this relation but considered that moisture was the more important factor limiting the outbreak of an effective epidemic of this disease.

Schuster ('12), working with the bacterial rots of potato, showed that at high temperatures (35°C.) saprophytic species, as, for example, *Bacillus fluorescens,* might become parasitic on potato tubers, causing soft rot.

Smith ('14) noted that in rapidly growing shoots of susceptible hosts the incubation period of *Bacillus Solanacearum* is shortened in very hot wet weather from 8–10 days to 2–3 days. He attributes the decrease to a difference in susceptibility in the host rather than to a change in the virulence of the invading organism.

Phycomycetes.—Perhaps more work has been done on the temperature relations of the *Phycomycetes* than of any other group of fungi, but the major part of these studies has been with its relation to spore germination.

Atkinson ('95) found that high temperature was a contributing factor to damping off by *Pythium deBaryanum,* which view is corroborated by Johnson ('14) working at Wisconsin, although neither of these authors show any experimental evidence to support their opinion.

Melhus ('11) showed that chilling the conidia of *Cystopus candidus* to a temperature of 8–10°C. produced the optimum germination and also infection in the case of the radish, and thus proved that this fungus is dependent on such chilling for its best development in its attack on the host.

Similar relations have been found to hold true in the cases of other *Phycomycetes*. From field observations covering a period of twenty years Lutman ('11) concluded that *Phytophthora infestans* required a fall in temperature for its best development on the potato. Melhus ('12) showed that the optimum temperature for spore germination in this species, both conidia and zoospores, was 8–14°C., thus corroborating the previous field observations. After the fungus has entered, however, he noted in a later paper ('13) that the disease was produced more readily at comparatively high temperatures, thus showing that, in this case at least, there was a difference between the temperatures favorable to parasitic growth, depending upon whether the infecting material be spores or mycelium.

Reed ('12), working with *Phytophthora infestans* on tomato plants, found that here again its attack was dependent upon low temperatures. The attack only occurred above the altitude of 2000 feet, and then only at times when there were cool nights.

Opposed to *Phytophthora, Plasmopara Viticola* has been found to be dependent on a rather high degree of temperature. Sajó ('01) observed this in 1900 as compared with 1899, the temperature in 1900 being higher throughout the summer than in the previous year. Again, in 1912, Ravaz and Verge ('12, '12[a], '12[b]) showed that for quickest germination a temperature of 22–27° C. was necessary for this fungus and that, since the fungus found water also necessary for infection, the host could only be attacked at periods of sustained high temperatures and humidity. Istvánffi and Pálinkás ('13) showed that not only were Ravaz and Verge correct, but that the development of conidiophores and conidia from the infected host was also somewhat dependent on these same temperatures.

Ascomycetes.—In the *Ascomycetes* but little has been done on the temperature relations of the parasitic forms. In Ohio, Selby ('99, '04) observed that the leaf curl of the peach, caused by *Exoascus deformans,* was favored in its occurrence by relatively low temperatures in April, May, and June, the weather in April having the greatest influence. These conclusions were based on observations made over a period of ten years, 1893–1903. Duggar ('09) showed that the same was true in New York. Pierce ('00) found that similar conditions brought about the attack in California, and attributed the virulence of the attack to the harmful action the adverse weather had on the host, causing it to be weakened. He also noted that hot dry weather would check an attack which had already started.

That *Sclerotinia Panacis,* the cause of black rot of the ginseng root, was favored by cold weather was shown by Van Hook ('04). This author found that this disease developed only in the winter, also a time when the roots were in a dormant state.

Germination of the spores of *Sphaerotheca Humuli* has been shown by Salmon ('00) to be increased if the spores were previously exposed to cold, especially freezing, temperatures. The germination, however, took place only when the higher temperatures were restored. Sajó ('01) observed that *Oidium Tuckeri* on grapes was favored by subnormal temperature and moisture.

Probably one of the first observations of scientific value on the relation of temperature to a particular plant disease was that made on the black rot of grapes by Buchanan in 1850. As is reported by Viala ('87), Buchanan noticed that this disease was worse after a period of hot weather. Viala also made observations on this relation and found that in hot weather (maximum 35–37°C., minimum 18–20°C.) there was a bad epidemic of the trouble. When the temperature fell the disease became checked. His observations covered a period of two years. Later Edson ('03), making observations in North Carolina, came to similar conclusions.

That reaction of different parasites to the temperature relations may differ even within a single genus, is well brought out in the genus *Glomerella*. Here, on the one hand, is found *Glomerella rufomaculans* which is dependent on a maximum temperature of 32°C. for the outbreak of an epidemic (Scott, '06), while on the other, *Colletotrichum Lindemuthianum* (*Glomerella Lindemuthianum* Shear) is reported by Edgerton ('15) as being unable to grow in culture above 31°C. He shows that this species causes the most severe injury at cool temperatures, infection being inhibited by the summer heat.

Fungi Imperfecti.—Little has been done as to this relation in the *Fungi Imperfecti*. Ravn ('00) has shown that in the case of *Helminthosporium teres*, the attack on barley was conditioned on cool temperatures at the immediate time of sprouting of the kernel in the soil. Similar conditions held for the stripe disease of barley, caused by *Helminthosporium gramineum*. By growing the plants under controlled conditions of temperature, this author was able to show that a temperature of 6.5–14°C. favored the disease, while a temperature of 19–25°C. practically excluded it from the seed-beds. He showed that the susceptible period for infection was immediately at the time of germination of the seedling, and that plants sprouted in warm temperatures, which were then immediately removed to cool conditions, did not become infected. Bakke ('12), in Iowa, showed that the optimum for growth of this fungus in culture was 23–25°C., so that it would appear that the effect of the temperature was one of resistance or escape on the part of the host rather than an effect on the fungus. Further evidence bears out this belief, since *Helminthosporium teres* can cause a leaf spot in the field at the higher temperatures.

The question of the temperature relations of the parasitic species of *Fusarium* will be discussed later and may be dismissed here with a brief statement that, as a rule, they seem to require high temperatures for their most virulent attack. In this they appear to be opposed to the closely related genus, *Verticillium*, which also causes wilt diseases (Wollenweber, '13).

In one other member of the *Fungi Imperfecti, Sphaeropsis Ellisii,* Petri ('13) has observed that the attack was dependent on cool humid atmospheric conditions, and the fungus was never seen in warm well-ventilated exposures. It is probable, however, that in this disease the limiting factor is moisture rather than temperature.

Basidiomycetes.—The temperature relations of the smuts and the rusts have been worked out more exactly than the other *Basidiomycetes.* Brefeld ('95), in experiments with oat smut (*Ustilago Avenae*), showed that when germinated spores were placed in soil and oats grown therein, 27–30 per cent of the plants became infected at 15°C., while at 7°C. 40–46 per cent were attacked. Tubeuf ('01), working with the same form, found the opposite results when ungerminated spores were used instead of germinated. He showed also that the spores of *Ustilago Avenae* cannot germinate under 5°C., their minimum for germination being between 5 and 9°C. As is pointed out by Hecke ('09), the difference in the findings is probably due to the fact that Brefeld germinated the spores before exposing the cultures to the different temperatures while Tubeuf did not. On account of this difference the time of susceptibility of the host was lengthened by the low temperature in Brefeld's experiments, and hence the increased infection; while in the experiments of Tubeuf the plants at low temperatures were held below the temperature of germination of the smut spores, and, therefore, the greater infection occurred at the higher temperatures.

In regard to the stinking smut of wheat (*Ustilago Tritici*), on the other hand, the minimum temperature for germination of both the wheat kernel (3–4°C.) and the spores of the fungus (5°C.) was practically the same, while the maximum for the smut germination (25°C.) was considerably lower than that of the wheat (30–32°C.), so that in this case the opposite facts were true, as Hecke ('09) showed. Therefore, the infection was favored by low temperatures and prevented by high (25°C.), because when the plant grew slowly the length of the susceptible period was increased. Munerati ('12) reports similar observations on wheat in Italy; early fall and

late spring planting favored the host, while late fall and early spring planting increased infection.

Among the rusts a similar relation between spore germination and infection occurs. Howell ('90), working on the clover rust (*Uromyces Trifolii*), showed that infection would take place only at comparatively low temperatures, the reason given being that it was only at the low temperatures that spore germination occurred; the maximum temperature for both uredo- and aecidiospores was in the neighborhood of 25°C. Marshall Ward ('01) in his notable experiments with the brome rust (*Puccinia dispersa*) showed that the optimum temperature for germination for this form was also at 18°C.

Eriksson ('95), in making experiments with rusts, and especially with the germination of spores of different forms, found that chilling the spores in the case of *Aecidium Berberidis, Peridermium Strobi, Uredo glumarum,* and *U. coronata* accelerated germination when they were brought back to higher temperatures. Johnson ('12), working with uredospores of *Puccinia graminis, P. rubigo-vera,* and *P. coronata,* showed that their optimum temperatures for germination were 12–17°C.; hence epidemics of grain rusts usually spread at periods of subnormal temperatures. From these observations it is easily seen that the rusts have developed the parasitic habit to a very special degree, adapting the temperatures when there is likely to be dew as those at which spore germination will take place, and thus aiding themselves in their attack on the host.

Balls ('08) has shown in some very careful work on the temperature relation of the *Rhizoctonia* causing "sore shin" of cotton that this fungus attacks the cotton plant at 20°C., but not at 33°C. He checked his work with observations on pure cultures of the organism, and found that at high temperatures the fungus secreted, or excreted, an inhibiting substance into the culture fluid which was injurious to the fungus. Whether this same toxic substance prevented that attack on the host is questionable.

As to the wood-destroying fungi, Falck ('07) found that *Merulius silvester, M. domesticus, M. sclerotiorum, Polyporus*

vaporarius spumarius, and *Verpa bohemica* all have a minimum temperature for growth of about 3°C.; *Merulius silvester, M. sclerotiorum,* and *Polyporus vaporarius spumarius* have an optimum of about 25°C., while the optimum for *Merulius domesticus* and *Verpa bohemica* is at 22° C. Their maxima are all at about 30°C. It was noted that these temperatures correspond very closely to those of *Phycomyces nitens* and *Mucor Mucedo,* as determined for comparison, although each species has a rate of growth that is constant for a given temperature (other factors being equal) and characteristic of that species.

With the exception of the genus *Fusarium,* the preceding covers the important work that has been done on the temperature relation of the parasitic fungi, as far as could be ascertained. It will be readily seen that the relation of temperature to the attack of a parasite is a complex one and depends entirely upon the individual diseases under observation.

To take up now the relations of temperature to diseases caused by *Fusarium,* Jones ('08) stated in his observations on the damping off of coniferous seedlings, caused by a member of that genus, that the trouble was facilitated by high temperatures. He was confirmed in this by Gifford ('11), working on the same trouble. Wollenweber ('13), however, was the first to show this relation in the case of the wilt diseases caused by *Fusarium.* He pointed out that these diseases occur most severely in the warmer climates, especially in the tropics and subtropics, but noted the cabbage yellows as an exception to this general rule. Previously, Wolf ('10) had noted, in the case of the wilt disease of pansy (*Fusarium Violae*), that the trouble was found only in July, and then only when the beds in which the plants were growing had been heavily covered with fresh horse manure, both of which facts suggest a dependence of the fungus on high temperature. This author made no mention of temperature, nor were any experiments on this relation reported.

Orton ('13, '14) in discussing the potato plant and its relation to disease has shown that in this instance Wollenweber's hypothesis held true, the Fusarium wilt having a southern

range as compared with *Verticillium albo-atrum* which caused a trouble of almost identical nature in the northern climates. Neither of these authors made controlled experiments to determine, if possible, exact ranges of temperatures.

Humphrey ('14), working in Washington with tomato blight caused by *Fusarium orthoceras* App. and Wollenw. and *F. oxysporum* Schlecht., found that the blight was favored by high temperatures. His statements were based on observations made on experimental plots in 1911 and 1914 at Pullman, Washington, coupled with the determination of the optimum temperature for growth of the organism in the laboratory at 86°F. or 30°C. This author suggested that the light intensity and wind are also factors in bringing about the typical symptoms of the disease.

A preliminary report (Gilman, '14) of the relation of temperature to the occurrence of cabbage yellows was made at the Philadelphia meetings of the American Phytopathological Society in 1915. The full report of this work is as follows:

Field observations.—On the experimental plot at Racine during the summer of 1912 it was observed that the attack of *F. conglutinans* occurred in the early part of July, when the plants had been set about two weeks. It was noted further that the plants which escaped or withstood the disease at this time remained healthy throughout the rest of the summer. Plants set out after this period were all practically immune. Upon looking up the temperature records of the summer it was found that the attack of the disease followed very closely a period of exceptionally hot weather. Table VII gives a summary of the observations made at three different times during the growing period. The strain numbers are those used by Jones and Gilman ('15) in the development of a variety of cabbage resistant to yellows. Strains II, III, and VI were commercial varieties of Danish Ball-head imported from Denmark; strains VII, VIII, IX, and X were from seed grown from resistant heads; strain XI was of the Flat Dutch variety imported from Germany; strain XII was commercial Houser; and strain XV, commercial Danish Ball-head. Further details may be found in the publication mentioned above. The

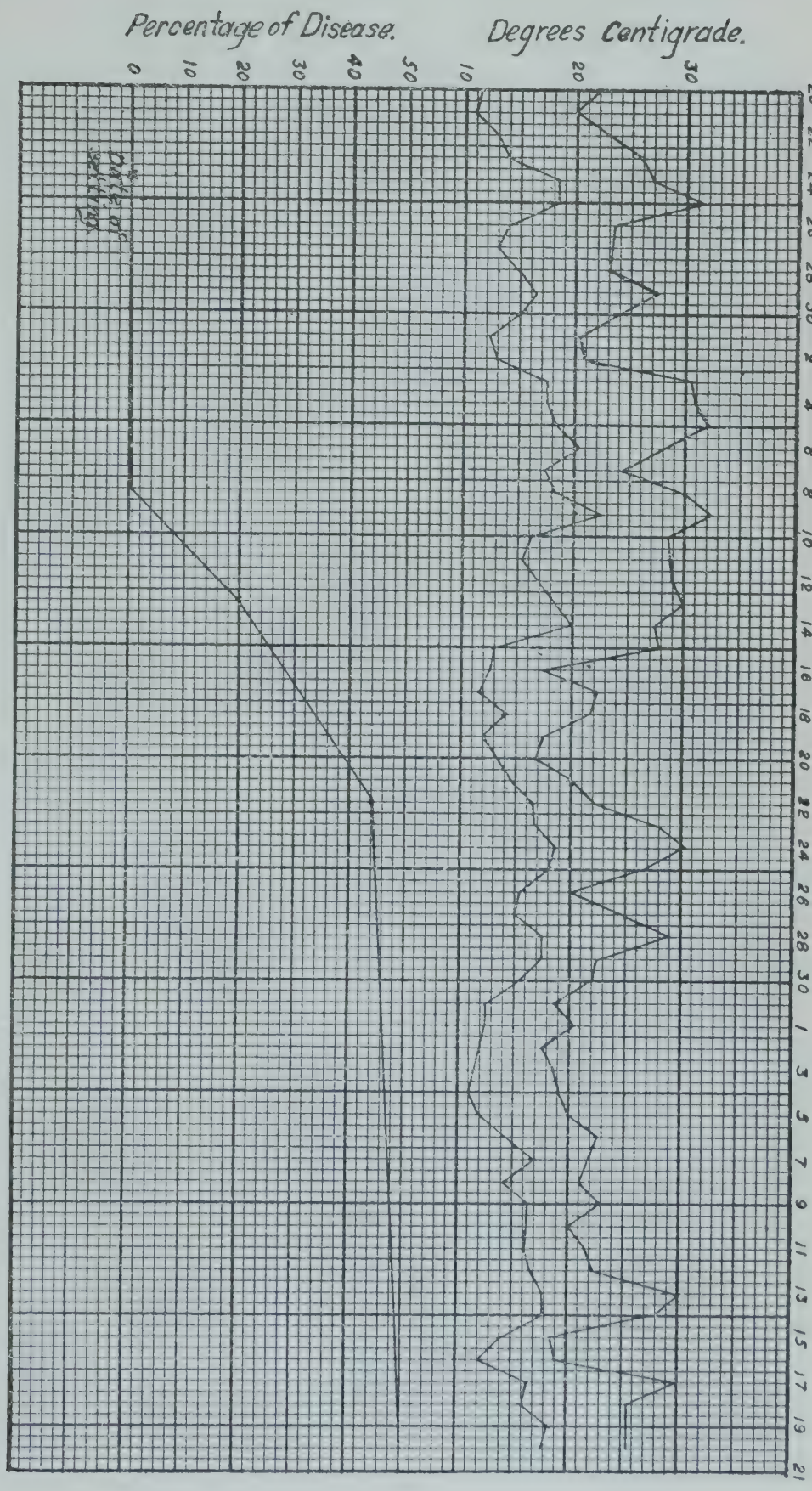

Fig. 13. Comparison of temperature with percentage of disease in field in 1912.

plants were set in the field June 24. The disease was beginning to show on July 8, when only 0.05 per cent of the plants were yellowed, and increased rapidly to 40.5 per cent on July 22. Of 420 plants set on July 15, after the hottest weather had passed, all remained healthy to August 21, but on account of the late planting did not make heads, and, therefore, were not considered later. The curves given in fig. 13 show the relation of the occurrence of the disease to temperature. The temperature data from which these were plotted are those published by the Milwaukee office of the United States Weather Bureau, a distance 25 miles north from the experimental field.

TABLE VII

SUMMARY OF FIELD OBSERVATIONS ON EXPERIMENTAL PLOT AT RACINE, WISCONSIN, 1912

Strain	Total no. of plants	July 16		July 22		August 20	
		Number yellow	Per cent yellow	Number yellow	Per cent yellow	Number yellow	Per cent yellow
II	45	18	4.0	32	71.1	37	82.2
III	45	3	6.6	24	53.3	32	71.1
VI	44	24	54.5	35	79.5	43	95.4
VII (a-y)	1039	284	27.3	551	53.0	567	54.6
VIII (a & b)	89	1	1.1	21	23.5	11	12.3
IX (3-116)	352	31	8.8	130	36.9	191	54.3
X (101-143)	625	97	15.5	195	31.2	234	37.4
XI	43	12	27.9	27	62.8	32	74.4
XII	39	5	12.8	18	46.1	17	43.6
XV	29	8	27.6	19	65.5	20	68.9
Total	2350	483	20.5	1052	40.5	1184	50.3

Again, in 1913, observations were made in the field on the same plot. The results of these observations are given in table VIII and fig. 14. Besides the strains used in 1912 several new commercial sorts were introduced. Strains XIII and XIV were Danish Ball-head bred locally, XIII being short-stemmed and XIV long-stemmed; strain XVI was Danish Ball-head grown by the Ferry Seed Company; XVII was All Season; XVIII, Succession; XIX, Volga; XX, Early Jersey Wakefield; XXI, Copenhagen Market; XXII, Early Summer; XXIII, Charleston Wakefield. While the experience of the

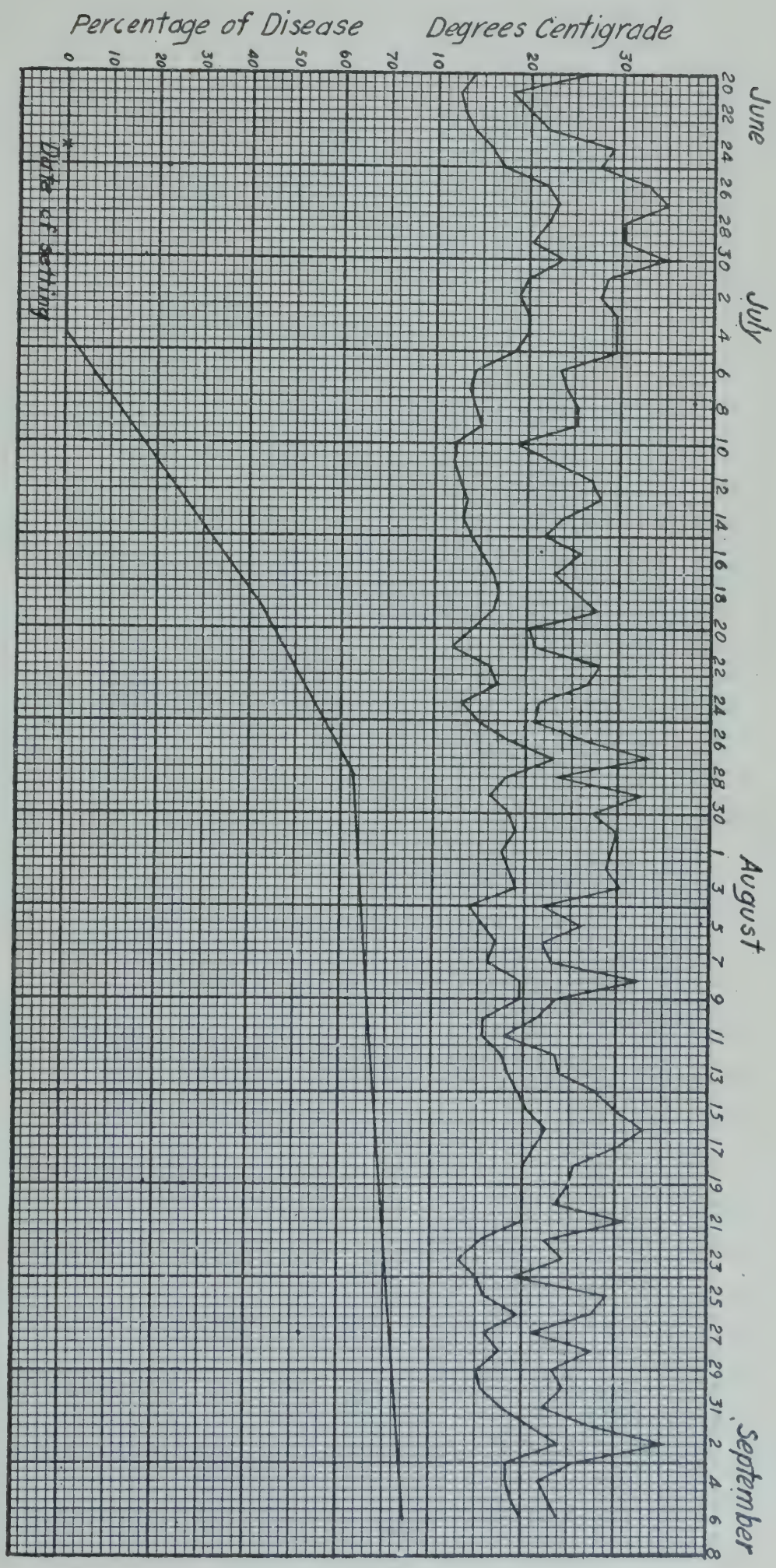

Fig. 14. Comparison of temperature with percentage of disease in field in 1913.

previous year was repeated, the relation between temperature and the attack was not as marked as it had been in 1912. The higher temperatures were sustained for a longer time, and, therefore, the percentage of disease continued to rise throughout the summer. The plants were set June 24, and no disease was found on July 4. Nevertheless, the main attack occurred in practically the same relation to the hottest weather as it had the previous year.

In 1914 the plants were grown on two experimental plots, and in addition to the strains mentioned above, a resistant strain from the Maryland Agricultural Experiment Station (XXIV) was added. The plants were set on June 26, and the disease was first observed on July 16, when 1.5 per cent of the plants showed the typical yellowing. Tables IX and X summarize the observations that were made during this summer.

TABLE VIII

SUMMARY OF FIELD OBSERVATIONS ON EXPERIMENTAL PLOT AT RACINE, WISCONSIN, 1913

Strain	Total no. of plants	July 19		July 28		September 6	
		Number yellow	Per cent yellow	Number yellow	Per cent yellow	Number yellow	Per cent yellow
II	50	28	56.0	42	84.0	47	94.0
III	46	28	60.8	34	73.9	34	73.9
VI	46	25	54.3	29	63.0	45	97.8
VII (a-y)	1243	639	51.4	874	70.3	795	63.9
VIII (a & b)	96	3	3.1	8	8.3	9	9.4
IX (3-116)	248	77	31.0	120	48.4	98	39.5
XI	47	19	40.4	21	44.7	33	70.2
XII	37	17	45.9	24	64.8	24	64.8
XIII (1-19)	820	301	36.7	489	59.6	748	91.0
XIV (1-11)	565	140	24.7	256	45.3	504	89.2
XV	985	556	56.4	707	71.7	827	83.9
XVI	43	11	25.6	25	58.1	42	97.6
XV I	40	17	42.5	26	65.0	32	80.0
XV II	28	19	67.8	20	71.4	26	92.8
XIX	42	15	35.7	17	40.5	12	28.5
XX	38	15	39.4	17	44.7	28	73.6
XXI	39	20	51.3	23	58.9	37	94.8
XXII	39	14	35.9	11	28.2	16	41.0
XXIII	33	17	51.5	17	51.5	23	69.7
Total	4485	1961	44.3	2760	51.9	3380	63.5

TABLE IX

SUMMARY OF FIELD OBSERVATIONS ON EXPERIMENTAL PLOT, HANSCHE FARM, RACINE, WISCONSIN, 1914

Strain	Total no. of plants	July 16		July 30		August 17	
		Number yellow	Per cent yellow	Number yellow	Per cent yellow	Number yellow	Per cent yellow
VIIf (1-9).....	162	3	1.85	46	28.40	54	33.33
VIIi (5-7).....	161	2	1.24	40	24.83	57	35.40
VIIIa (7-35)....	810	0	0.0	8	0.99	10	1.23
VIIIb (3-14)....	385	0	0.0	8	2.08	19	4.94
X 135.....	81	0	0.0	9	11.11	16	19.75
X 143.....	81	0	0.0	8	9.87	15	18.50
X 135 (2-33)...	782	3	0.38	145	18.54	168	21.48
X 143 (2-38)...	1213	2	0.16	215	17.72	318	26.22
XV.....	482	27	5.6	374	77.59	433	89.83
XVI.....	299	5	1.67	144	48.16	236	78.93
XII.....	81	11	13.6	67	82.7	64	79.0
XIII-11.....	81	1	1.2	69	85.2	80	98.76
XIV-8.....	81	0	0.0	62	76.5	74	91.35
XIX.....	81	1	1.2	14	17.3	19	23.45
XXIV.....	81	0	0.0	6	7.4	5	6.17
Total.....	4861	55	1.13	1215	24.78	1568	32.05

TABLE X

SUMMARY OF FIELD OBSERVATIONS ON EXPERIMENTAL PLOT, BROESCH FARM, RACINE, WISCONSIN, 1914

Strain	Total no. of plants	July 16		July 30		August 17	
		Number yellow	Per cent yellow	Number yellow	Per cent yellow	Number yellow	Per cent yellow
VIIf (5-7).....	476	7	1.47	158	33.19	262	55.0
VIIi (2-6).....	475	4	0.8	172	36.2	267	56.21
VIIIa (7-35)....	2352	0	0.0	57	2.42	176	7.48
VIIIb (3-18)....	1175	0	0.0	68	5.78	136	11.57
X 135 (8-21)...	1204	0	0.0	315	26.16	594	49.34
X 143 (2-38)...	2379	16	0.67	945	39.72	1477	62.08
XIII 11.....	238	0	0.00	175	73.5	231	97.1
XIV 8.....	236	7	2.87	170	72.0	225	95.8
XV.....	476	137	28.78	448	94.1	454	95.35
XVI.....	479	1	0.2	289	60.3	426	88.9
Total.....	9490	172	1.81	2797	29.47	4248	44.65

A soil thermograph was installed in the experimental plot; the bulb was placed six inches below the surface of the soil, and records were kept covering the growing period. These show that the temperature of the black clay loam, such as is found in Racine and Kenosha counties in Wisconsin, is comparatively high, the minimum temperature of the soil rarely falling below the minimum for the air, and the maximum temperature of the soil, because of the lag, often exceeding that of the air, especially on cold or cloudy days (fig. 15). The same relation between the main attack of the disease and temperature is apparent, although, because the high temperatures were maintained throughout July and August as they had been the previous summer, the percentage of disease also increased over a longer period than in 1912. The total percentage of the disease in this year was less than in the previous years, because plants from the resistant strains were counted with the control, the totals from the entire plot being used.

Experimental results.—The experiments to show the relation between temperature and the attack of the fungus were started in 1913. For this phase of the investigation the plants were grown in uniformly diseased soil in two different greenhouses, one of which was kept as near 25°C. as possible and the other at 15–20°C. In the first experiment three flats of infected soil and one of greenhouse soil (uninfected) were placed in the warm house, and one flat of infected soil and one of uninfected greenhouse soil were placed in the cool house. The flats were planted on October 4, 1913, with two hundred seeds in each flat. The steam was turned on November 18, at which time the plants in all the flats appeared normal in their development. On November 25, however, yellows appeared in the flats of infected soil in the warm house. The plants in uninfected soil in both houses remained healthy. Figures 16–18 give an idea of the range of temperatures in the two houses for the entire period during which these experiments were made.

On December 6 the above experiment was repeated; four flats of infected soil were planted, and two placed in each

Fig. 15. Comparison of air and soil temperatures with percentage of disease in field in 1914; air temperature, solid line; soil temperature broken line.

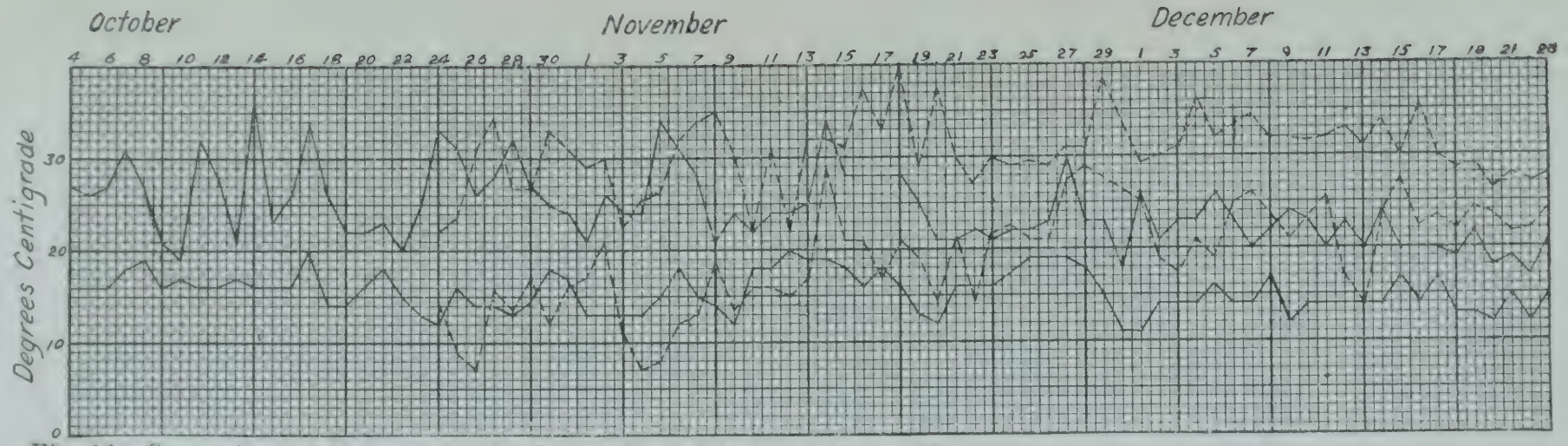

Fig. 16. Comparison of temperatures in House IIc with those in House IIa, October 4–December 23, 1913; House IIc, broken line; House IIa, solid line.

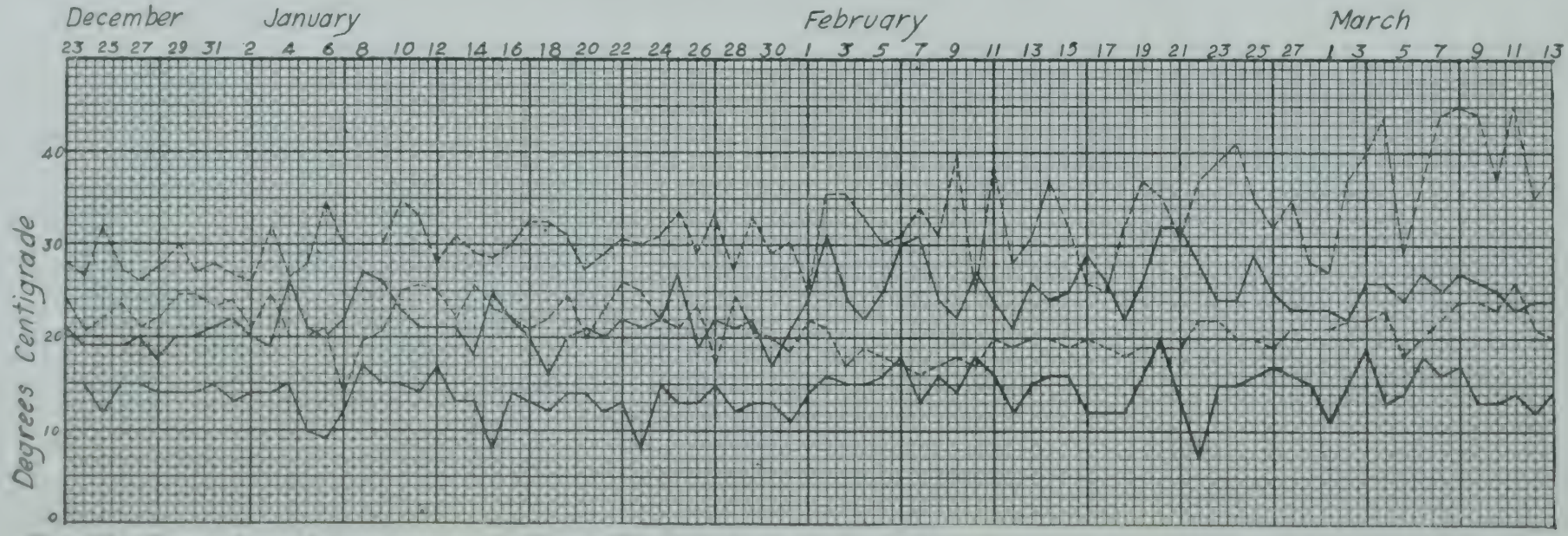

Fig. 17. Comparison of temperatures in House IIc with those in House IIa, December 23, 1913–March 13, 1914; House IIc, broken line; House IIa, solid line.

house. The yellows appeared in the warmer house on December 29. Each of the seedlings showing the symptoms of the disease was sterilized by placing the entire seedling in hydrogen peroxide and washing in sterile water. It was then placed on potato hard agar. The fungus grew readily from the stem of the infected seedlings, as is shown in pl. 2, figs. 8–11. The flats of infected soil were interchanged, and after replanting on January 29, the results were found to be the same; that is, the plants in the warmer house showed the disease, while those in the cooler house remained healthy. The first disease symptoms were observed on February 10.

During the above experiments the temperatures were as constant as they could be made in a greenhouse where the steam supply was regulated by means of an automatic thermoregulator. Of course, the heat on very sunny days was much greater than desired, but this factor could not be controlled, as shading caused too rapid elongation of the plants and a consequent susceptibility to damping off. It was found, however, that the soil temperatures were fairly constant, being from 23 to 26°C. in the warmer house and from 12 to 16°C. in the cooler house. These determinations were made directly by placing the thermometer bulb two inches below the surface of the soil and after the mercury had come to rest making the reading.

In one experiment the number of plants used in the trial was noted, and the percentage diseased after an exposure of three weeks calculated from actual count. The experiment was started January 29, 1914. The trial consisted of seven pots of infected soil, and two pots of normal greenhouse soil for controls. Five pots of infected soil were placed in the warmer greenhouse and two in the cooler house. One pot of the normal greenhouse soil was placed in each house. The disease was found first on February 10, and the plants were pulled and counts made on February 21. If the experiment had been continued, doubtless all the plants in the warmer house would have been destroyed, as they had been in the other experiments. Table XI gives the results.

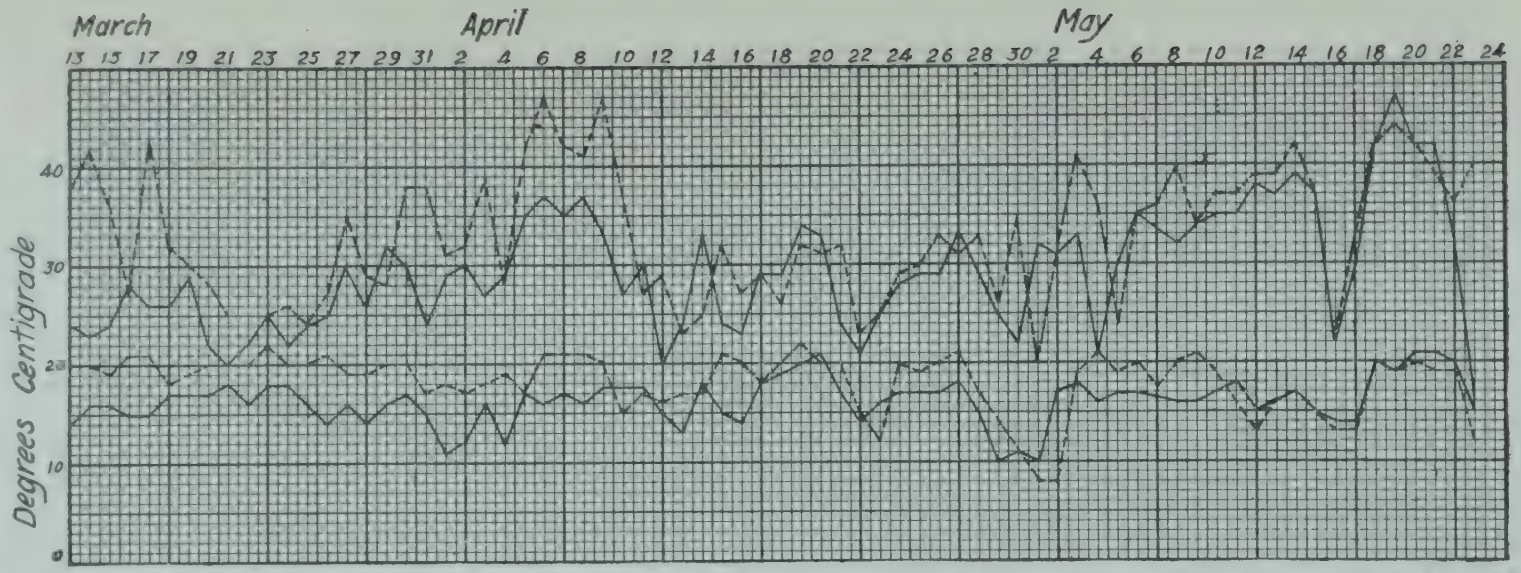

Fig. 18. Comparison of temperatures in House IIc with those in House IIa, March 13–May 23, 1914; House IIc, broken line; House IIa, solid line.

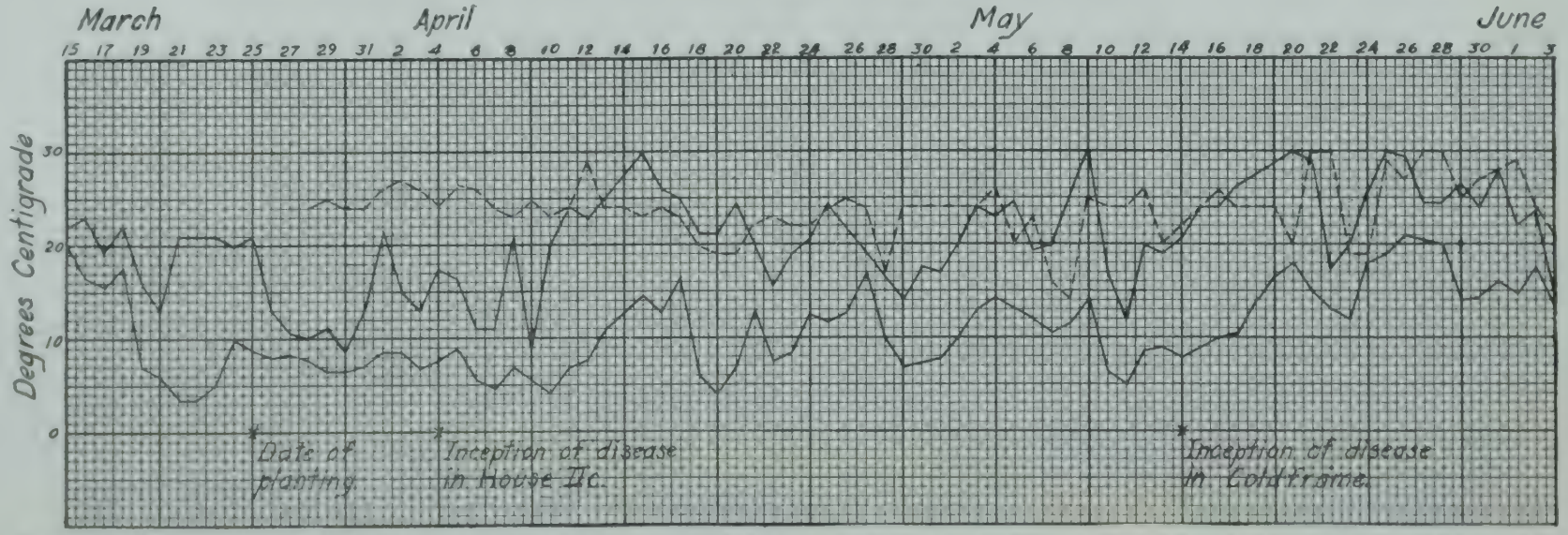

Fig. 19. Comparison of soil temperatures in the cold-frame with those in House IIc, March 15–June 3, 1914; cold-frame, solid line; House IIc, broken line.

TABLE XI

AMOUNT OF YELLOWS PRESENT AFTER AN EXPOSURE OF THREE WEEKS TO HIGH AND LOW TEMPERATURES

Pot no.	Soil	Temperature	Total no. of plants	After three weeks' exposure	
				No. diseased	Per cent diseased
1	Infected	25° C.	73	27	37
2	Infected	25° C.	69	25	38
3	Infected	25° C.	60	16	27
4	Infected	25° C.	54	20	37
5	Infected	25° C.	44	18	41
6	Infected	15–20° C.	60	0	0
7	Infected	15–20° C.	49	0	0
8	Uninfected	25° C.	119	0	0
9	Uninfected	15–20° C.	58	0	0

Again, on February 21, the effect of transplanting normal plants to infected soil at different temperatures was tried. Fifty normal plants were placed in two flats of infected soil

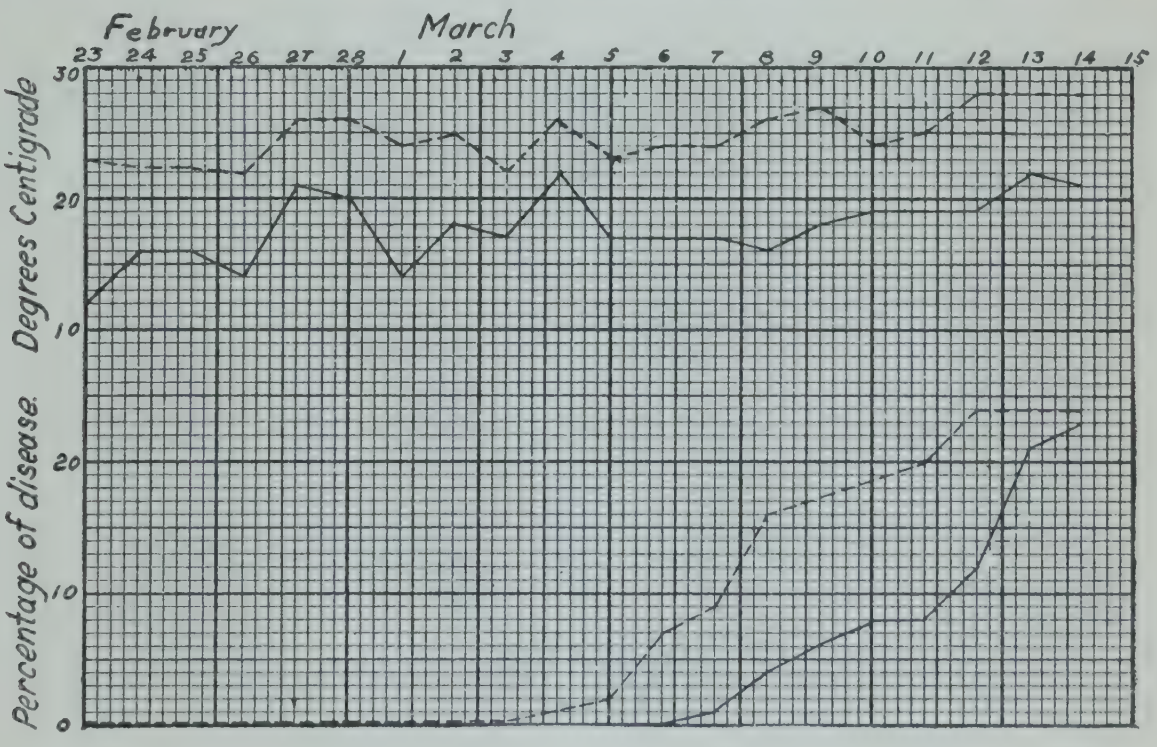

Fig. 20. Comparison of soil temperatures in House IIc and those in House IIa with the occurrence of yellows in the respective houses; House IIc, broken line; House IIa, solid line.

and one flat placed in each house. Controls consisted of ten normal plants from the same flat as the above, placed in normal greenhouse soil in two pots, one pot in each house. Soil

temperatures were taken daily. The results are not conclusive, as the temperature in the cooler house rose to 21°C. on the sixth day and remained high for two days, nor did it go back to below the temperature at which infection took place. Nevertheless, the symptoms appeared in the warmer house March 4, three days before the plants in the cool house showed any sign of the trouble, and the cooler soil retarded the advance of the fungus proportionately, as may be seen from the curves (fig. 20).

In further experiments on this temperature relation a cold-frame was used as a means of maintaining cooler conditions, for the greenhouses were all too warm, due to the increased intensity of sunlight, especially at midday. The north side of the potting-house, where the sun was excluded, made it possible to carry these cultures still further into the spring, and in all cases the results were the same.

In the experiment in which the cold-frame was used, a soil thermograph of the type manufactured by Julien P. Friez was installed. The bulb was imbedded four inches in the soil, and the temperature of the soil and air were recorded throughout the experiment. The plants were started on March 25 in six flats of uniformly infected soil, three of which were placed in the greenhouse at 25° C. and three in the cold-frame. Two pots of greenhouse soil, planted to cabbage, were used as controls in each case. The disease appeared first in the greenhouse on April 4, ten days after planting. Seedlings were plated from the diseased flats and from the flats in the cold-frame on April 9, and in all cases the diseased seedlings showed the fungus growing from the stem, while the controls remained sterile. On April 13, photographs were made of two of the flats—one from the cold-frame showing the healthy condition of the seedlings, and one from the greenhouse showing the ravages due to the attack of the fungus (pl. 2, fig. 7). The temperature records show that there was an increase in temperature with the advance of the season, and it was due to this increase in temperature that the attack occurred. The curves (fig. 19) do not show this fact well, as they are a record of the maximum and minimum only and do

not show the duration of temperature in any one day. The records themselves, while they cannot be presented here, show this increase more markedly—for the length of time of the higher temperatures increased—as the spring gave way to summer conditions. In any case the cooler condition prevented the attack of the fungus for at least a month.

In the experiment in which the flats were placed on the north side of the potting-shed, three flats of diseased soil were used. Two were placed on the north side of the potting-shed, and the third in the warm house. The flats were planted April 9, and yellows appeared in the flat in the greenhouse on April 17, while none was found, up to May 26, in the flats kept outside. Soil temperatures covering this period are shown by the curves in fig. 21.

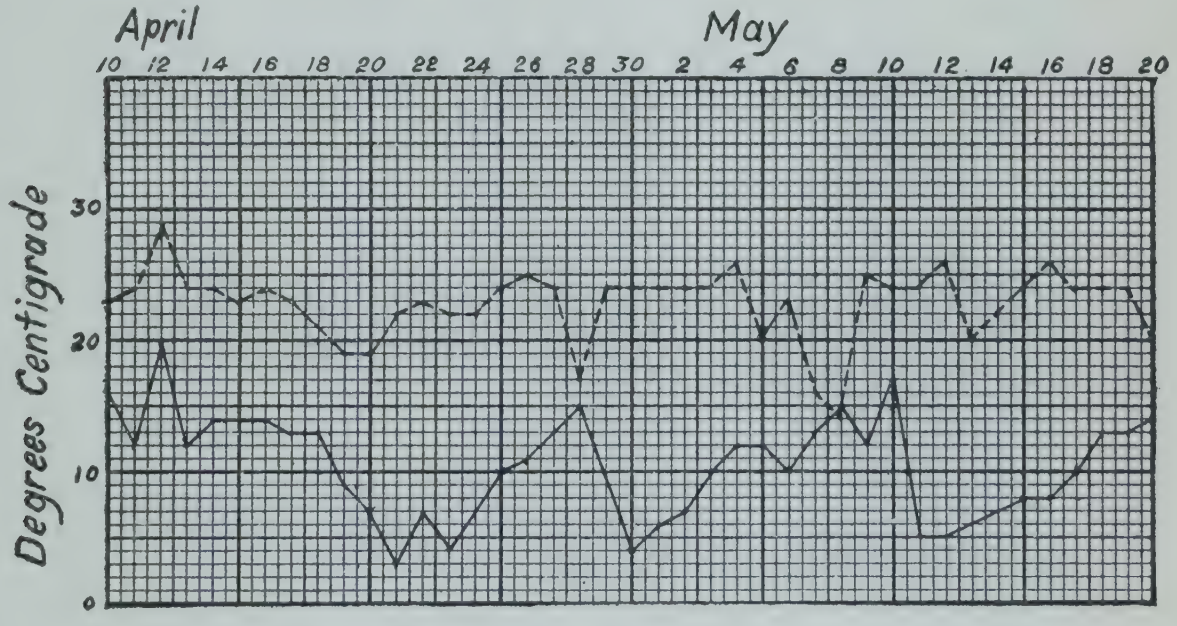

Fig. 21. Comparison of soil temperatures in House IIc with those on north side of potting-shed, April 10–May 20, 1914; House IIc, broken line; north side of potting-shed, solid line.

Further work was undertaken at the Missouri Botanical Garden to try to determine the lowest point at which the attack may occur. To this end two glass incubators were set up, and the temperature was controlled by an electric thermoregulator, so that it varied but a degree or two at the most. One incubator was set up in the laboratory at a west window, and the other was placed on the north side of the building. The temperature of the incubator in the laboratory was kept

at 22–24°C., this being the lowest constant temperature that could be procured in the room. The incubator outside was set at 16°C., but on account of the wide variation in atmospheric temperatures it was not possible to keep it constant at this point. At times the temperatures reached as high as 21°C., and at other times as low as 10°C. In spite of this variation no yellows occurred in the incubator which was outside until some days after all the plants in the warmer incubator had been attacked. Twenty pots of soil from the experimental field at Racine were placed in the warm incubator and twenty similar pots were placed in the cool incubator. The pots were put in the incubators on November 5, 1914, and in four days the plants in one pot showed wilting. The plants were sixteen days old when they were submitted to the trial. Previous to this time they had been growing in the greenhouse which was kept at 12–14°C. On November 11 yellowing was apparent in all the pots except the controls, some of the plants also showing wilting. In the outside incubator but two plants showed a slight yellowing and there was no wilting. Damping off due to *Rhizoctonia* was rather extensive in some of the pots because of the relatively high humidity conditions. Counts were taken on November 14 of the plants in the warm incubator, and seedlings from both incubators were plated on potato hard agar. The results were as follows:

At 22–24°C. *F. conglutinans* was isolated from plants from every pot of the infected soil, while none could be isolated from the plants in the normal greenhouse soil. When the plants from eight pots of infected soil, growing at 10–16°C., were plated *F. conglutinans* was isolated from but one; the fungus was not isolated from the controls. In the twenty pots at 22–24° C. there was a total of 104 plants, seven of which remained healthy, while in the incubator at 10–16° C. there was a total of eighty-eight plants, only one of which showed the disease even after they had been left until December 1 in the incubator. Table XII summarizes the results obtained on this temperature relation.

TABLE XII

SUMMARY OF RESULTS OF EXPERIMENTS TO SHOW THE RELATION OF TEMPERATURE TO ATTACK OF THE FUNGUS

Incubation period in days	Extent of trial				Approximate average temperature in °C.		Condition of control at inception of disease
	Infected soil		Uninfected soil				
	Higher temperature	Lower temperature	Higher temperature	Lower temperature	Higher	Lower	
13	3 flats.	1 flat..	1 flat..	1 flat..	22°	16–20°	Healthy..
21	1 flat..	1 flat..	1 pot..	1 pot..	22°	16–20°	Healthy*.
30	10 pots.	12 pots.	1 pot..	1 pot..	22°	14–16°	Healthy..
4	20 pots.	20 pots.	3 pots.	3 pots.	22–24°	10–16°	Healthy*.
23	3 flats.	1 flat..	1 flat..	1 flat..	25°	14–18°	Healthy..
12	3 flats.	1 flat..	1 flat..	1 flat..	25°	14–18°	Healthy..
12	7 pots.	5 pots.	2 pots.	2 pots.	25°	14–18°	Healthy..
8	2 flats.	1 flat..	2 pots.	2 pots.	25°	14–16°	Healthy..
10	3 flats.	3 flats.	2 pots.	2 pots.	30°	14–16°	Healthy*.

*In these cases the controls in infected soil at the lower temperatures became diseased later, due to a rise of temperature above the point at which they were able to resist the disease.

In a further experiment seeds were planted on October 20 in pots of infected soil and allowed to stay in the greenhouse. The soil temperature was 10–16°C., and while a little disease appeared from time to time after December 1, 1914, the attack was very light and very few of the plants suffered. When on February 2, five pots of these plants were taken to a greenhouse whose air temperature was 28–30°C., yellows appeared in virulent form in three days and all but three plants were dead on February 20. Plate 1, fig. 3, shows typical pots from this experiment. It was repeated February 28 with similar results.

The fact that high temperatures caused the yellowing of the cabbage when the plant was attacked by *F. conglutinans* having been clearly established, the next point was to find, if possible, whether the fungus entered the host at the lower temperature or not. The first experiments were made by plating from the plants in the lower temperatures, especially from parts of the roots of plants grown in infected soil. Although the plates were made in the same manner and with the same

care as in the case of the yellowed seedlings grown at higher temperatures, at no time was *F. conglutinans* isolated from the roots of these plants. Controls from roots grown at the higher temperatures showed the fungus, as has been pointed out in previous experiments. Experiments were therefore instituted to test whether any such relation might be indicated by indirect methods.

The first experiment was started on April 21, 1914, at which time twenty pots of infected soil were planted to cabbage, and all were placed on the north side of the pottingshed where a low temperature could be maintained. They were kept here until June 6, sixteen days, when all but two were placed in House IIc which was being kept at approximately 25°C. On June 9, after the pots had remained in the warm house for three days, pairs of pots were removed to the cooler temperature at intervals of two days until June 15, after which date a pair was removed each day until June 19. On June 30 yellows appeared in the two pots removed on the last day, June 19, but none was found in any of the other pots. This experiment showed that in this case the yellows appeared in the same length of time as it usually took to appear in a warm house, and would lead to the opinion that there had been no infection at the low temperature, or if the plants had been attacked, that they were able to recover under favorable conditions for growth.

Coincident with this last experiment, moreover, twenty pots of infected soil planted to cabbage were placed in House IIc, and each day two pots were removed to the cooler temperature. No yellows appeared in any pots removed in the first eight days, but in all those removed subsequently yellowing was found on June 2. Controls in the warm house showed the first symptoms on June 1, one day earlier than those on the outside. The cooler temperature, therefore, checked the disease in most cases, but where it had gone too far, the only effect was a slight lengthening of the period of incubation.

Later observations on this point do not seem to confirm these results. It will be noted that in the experiments carried on at the Missouri Botanical Garden, when the plants

were first grown in the greenhouse and then placed in the incubator at 22–24°C., the disease appeared in but four days, a period that was shorter than had been noted in any other experiment. This trial was repeated on March 9, and again the seedlings showed the disease in four days, on March 13. Eight pots of seedlings were used, and the disease appeared in all the pots on the same day, although not all the seedlings in any one pot were yellow at this time. Previous to the appearance of the yellows, platings made from the roots by the hydrogen-peroxide method gave negative results in all cases. Further, the roots were washed out of the soil and examined carefully under the microscope, but no hyphae of the fungus were observed until after wilting or yellowing had begun. The rotting usually began at the tips of roots near the surface of the soil, and progressed toward the main roots and stem. The only explanation that seems applicable to these conflicting results is that, because the temperature in the greenhouse at the Garden is slightly higher than that found on the outside of the potting-shed, the fungus may enter to a limited extent, but cannot affect the host unfavorably except at the higher temperature, while at Madison it was unable to gain any sort of a foothold. This view is further supported by the fact that a few plants grown in diseased soil in this greenhouse, after a long period of time showed yellows, as previously mentioned.

Because the small number of hyphae found in any single diseased stem seemed insufficient for the blocking of the passage of water to the leaves of the diseased plant, some preliminary work was undertaken to find, if possible, whether mechanical or chemical killing of the stem might bring about symptoms in the leaves similar to those produced by the fungus, and especially with regard to the production of a toxic substance to which the symptoms might be ascribed.

To test this question six plants of cabbage were cut on one side with a scalpel so that half of the stem was removed for a distance of 0.5 cm. The plants were about two weeks old and growing rapidly. The cut surfaces were covered with paraffin to prevent too rapid drying of the tender tissues. Two

plants showed wilting in nine days but the others all remained upright and turgid, having completely recovered. There was no discoloration of the leaves in connection with the wilting.

In a later experiment with older plants, the entire stem of each plant was killed for a distance of 3 cm. from the surface of the ground by allowing it to stand in alcohol for three minutes. After nine days, wilting appeared in one of the five plants, the lowest leaves drooping first, but with no discoloration such as occurs under the influence of fungous attack, nor falling of the wilted leaves. A second plant succumbed on the twelfth day, but again there was rapid wilting with no loss of green coloring matter. By the eighteenth day all the plants had wilted, but even where the injury had been least and the wilting slowest there was no discoloration or falling of the leaves. The experiment was repeated with older plants in March, 1915, with similar results. The wilting always took place without discoloration of the leaves, nor did any of them drop before the entire head was wilted.

Further work was started, therefore, to see whether the fungus could produce in pure culture any substances toxic to cabbage. For this study two Erlenmeyer flasks of half-liter capacity, each containing 100 cc. of Uschinsky's fluid, were inoculated with a virulent culture of *F. conglutinans*. After two weeks the fungus-felt was filtered from the solution by means of a pressure filter, and the solution, after dilution to 500 cc., was poured in two glass tumblers, in which germinated cabbage seedlings were then placed. Controls of Uschinsky's fluid diluted 2:5, tap water, and Pfeffer's full nutrient were used in connection with the experiment. Difficulty was experienced in getting the plants to start because of the desiccation of the young cotyledons. By placing the plants in an incubator under humid conditions, the plants growing on tap water and Pfeffer's solution grew fairly well, but on Uschinsky's fluid, neither on that in which the fungus had been growing nor on the sterile fluid, was it possible to get any growth, indicating that some other media or methods will have to be used. Further work on this point is being pursued.

Discussion.—Exactly why the raising of the temperature should bring on this disease is still not clear, but in view of our present knowledge some correlation should be made between the relations found and the other work that may shed light on this point. First, it should be pointed out that many of the so-called vascular parasites behave in a very similar manner toward temperature. As Smith ('14) has shown with *Bacillus Solanacearum,* Humphrey ('14) with *Fusarium orthoceras,* and the present investigation with *F. conglutinans,* high temperatures facilitate the destruction of the host. To what extent this destructiveness may be attributed to changes in the parasite and to what extent to changes in the host plant, it is difficult to determine. Smith and Humphrey both are inclined to consider the changes in the host the primary factors concerned, and as will be pointed out, the same opinion may be taken in the case of the cabbage disease. Nevertheless, the change in the fungus must be looked into also.

Among diseases of plants that are partially dependent on temperature relations for their occurrence, in many of the cases the relation is not one of loss of virulence on the part of the fungus but a limitation in the temperature range of germination of the fungous spores. This sort of limitation was best illustrated by the work of Melhus ('12, '13) on *Phytophthora infestans* as related to the potato blight. This author showed that, although the spores germinated only at low temperatures, the mycelium which wintered over in the tuber, attacked the new shoots from such tubers only at high temperatures. Other cases of similar nature, where the temperature for spore germination differed from that of mycelial growth, are found among many of the obligate plant parasites. Examples that might be cited are *Cystopus candidus, Plasmopara Viticola, Ustilago Avenae, U. Tritici, Uromyces Trifolii, Peridermium Strobi, Puccinia graminis, P. rubigo-vera, P. dispersa,* and *P. coronata.*

That *Fusarium conglutinans* is not dependent on germination temperatures for its destructive attack is clearly shown by the fact that germination occurs readily at 17°C., which temperature is close to the lower limits of its destructiveness

in the case of cabbage. Moreover, it grows readily at temperatures much lower than this. The raising of the temperature merely increases the rapidity of the growth of the fungus and, therefore, as far as this investigation is concerned, the high temperature from the standpoint of the fungus aids its destructiveness by increased spread in the soil, and more rapid development in the vascular system after it has once entered. Other possible relations, such as that of production of toxic substances, remain to be worked out.

From the host standpoint the effect of temperature is much more complicated. Appel ('15) in his discussion of leaf roll in potato considered excessive transpiration of prime importance in bringing about this condition whether the cause of the trouble was parasitic or not. The symptoms of the disease in the cabbage indicate that the phenomena involved are very similar to those concerned with the annual autumn fall of leaves from woody plants. The discoloration (yellowing in the diseased plants), the formation of an abscission layer, and finally the fall of the leaves are in all ways comparable. Hence the same physiological changes within the plant are probably taking place. From this point of view then, the work of Molisch ('86) and Varga ('11) on the relations of environmental factors to the fall of leaves gives a basis for an explanation of the symptoms from the host standpoint. Molisch showed that a slow but continued decrease of water content of the fundamental tissue of the leaf led to the formation of an abscission layer and finally fall of the leaf. He further found that this loss of water might be brought about by increased transpiration or by decreased absorption or conduction from the roots to the leaf. Temperature influenced leaf-fall, both indirectly through its effect on transpiration, and directly by bringing about the formation of the abscission layer. Leaves fell at 17–22°C. more rapidly than at 1–10°C. when other conditions were equal. Varga studied the relation of temperature to leaf-fall more exactly and found that, as a rule, low temperatures lowered transpiration and thereby set up a stimulus to leaf-fall, but that if the abscission layer had been formed through other influences, higher tempera-

tures within limits, caused a more rapid fall of the leaves. These facts give a possible explanation of the results found with cabbage yellows. The hyphae of *F. conglutinans* in the fibro-vascular bundles cause a constant but slow drain on the water content of the plant, which causes the formation or the beginning, at least, of the formation, of the abscission layer. High temperatures, in addition to causing increased growth of the fungus, raise the transpiration and also stimulate leaf-fall; thus all the factors are cumulative in their effect.

The reason that mechanical and chemical injuries to the stem did not cause similar symptoms may be explained by the fact that the plants wilted before sufficient time was given for the formation of the abscission layer and, therefore, the difference in symptoms. This theory also concurs with that of Humphrey in regard to the tomato blight, but a large amount of work is still necessary before it will be completely proven.

Summary

Cabbage yellows is a wilt disease of cabbage caused by *Fusarium conglutinans* Wollenw.

The fungus is a facultative parasite living in the soil, from which, under certain conditions, it becomes destructive to cabbage.

The fungus has a high optimum temperature and is very resistant to drying—both in pure culture and in the soil.

Inoculation experiments with *Fusarium conglutinans* in pure culture caused the disease in a large percentage of the trials. Control plants remained entirely free from the yellows. *Fusarium conglutinans* was recovered from inoculated diseased seedlings and again produced the disease upon inoculation.

Variation in virulence of the cultures and in susceptibility of the host caused many artificial inoculations to be unsuccessful, resulting in less than 100 per cent infection.

Mechanical or chemical injury to the stem of the host caused wilting, but neither yellowing nor dropping of the leaves such as is found in diseased seedlings.

The characteristic symptoms are dependent on a temperature of about 17–22°C. or above for their occurrence. Lower temperatures (12–16°C.) under controlled conditions prevented the occurrence of the trouble in the greenhouse.

Observations made in the field during the summers of 1912, 1913, and 1914 bore out this relation between the occurrence of the disease and high temperature.

In conclusion, the writer wishes to express to Dr. L. R. Jones, at whose suggestion this investigation was undertaken, and to Dr. B. M. Duggar, under whom it was completed, his sincere appreciation of the many valuable suggestions and helpful criticisms given during the progress of this work. He is further indebted to the support of the Wisconsin Experiment Station for the opportunity of conducting the initial stages of the work and to the Missouri Botanical Garden for the completion of the work upon the problem.

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Explanation of Plate

PLATE 1

Fig. 1. Results of inoculation in the greenhouse with pure cultures.
Pot No. 1. Infected soil, sterilized.
Pot No. 2. Sterilized soil inoculated with pure culture of *F. conglutinans.*
Pot No. 3. Soil from infected field, untreated.
Madison, Wisconsin, July 14, 1913.

Fig. 2. Results of inoculation in the garden with pure cultures.
Pot No. 1. Infected soil, sterilized.
Pot No. 2. Sterilized soil inoculated with pure culture of *F. conglutinans.*
Pot No. 3. Soil from infected field, untreated.
Madison, Wisconsin, July 14, 1913.

Fig. 3. Effect of temperature on the attack of *F. conglutinans* on cabbage.
Pot No. 1. Uninfected soil in cool house.
Pot No. 2. Infected soil in cool house.
Pot No. 3. Infected soil in warm house.
Pot No. 4. Uninfected soil in warm house.
Missouri Botanical Garden, March 1, 1915.

Fig. 4. Diseased cabbage plant showing typical one-sided bending of leaf and loss of lower leaves. Madison, Wisconsin.

Fig. 1

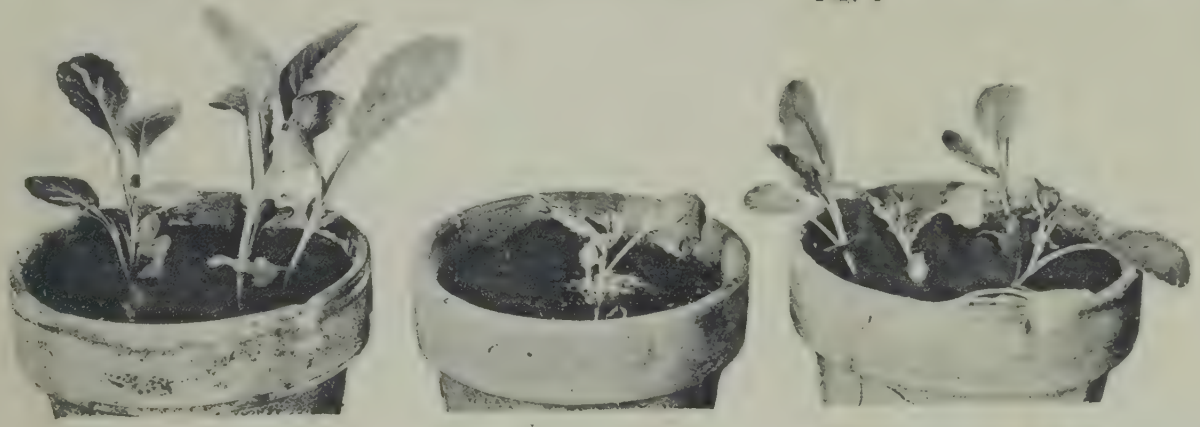


Fig. 2

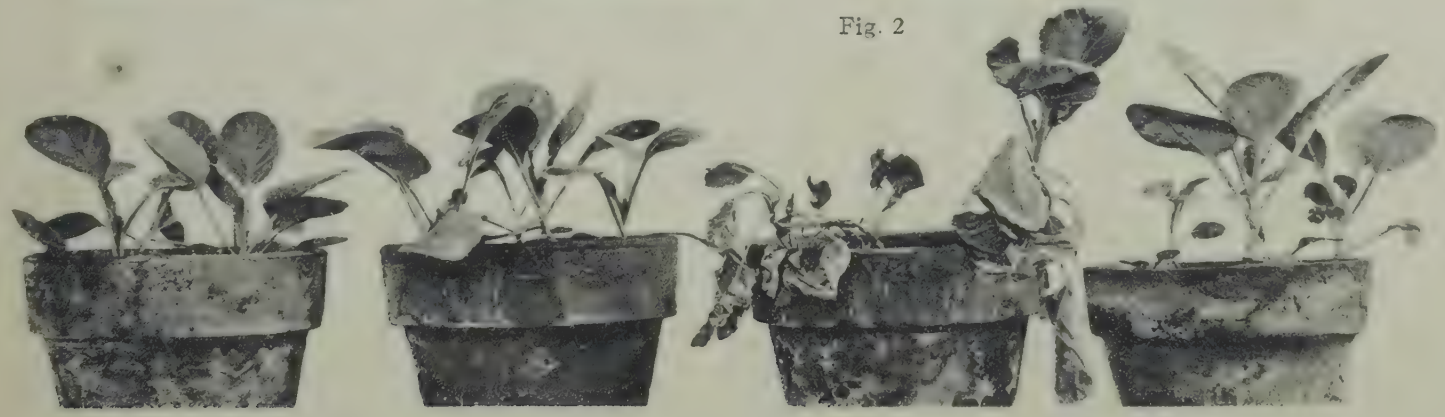


Fig. 3

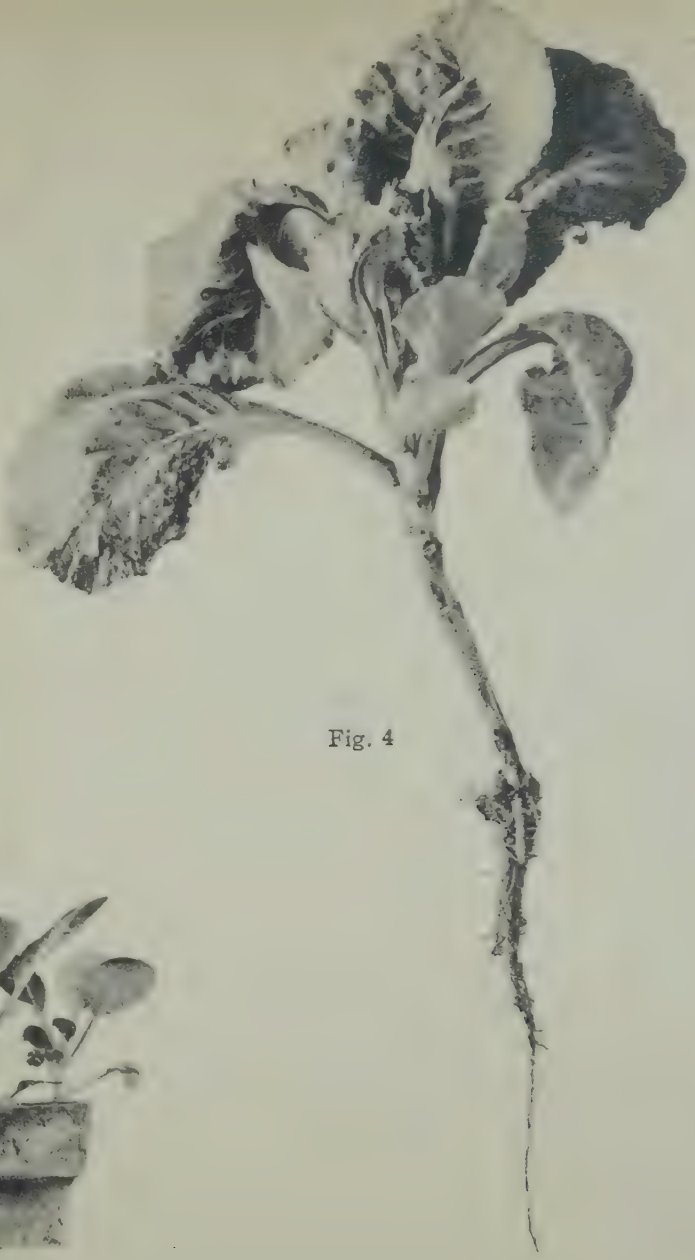


Fig. 4

Explanation of Plate

PLATE 2

Figs. 5 and 6. Comparison of rate of germination of resistant and commercial varieties of cabbage under the same conditions. Fig. 5, commercial sort; fig. 6, resistant. Missouri Botanical Garden, November 5, 1914.

Fig. 7. Effect of temperature on the attack of *F. conglutinans* on cabbage. On left, flat from cold-frame; on right, flat from House IIc. Madison, Wisconsin, April 13, 1914.

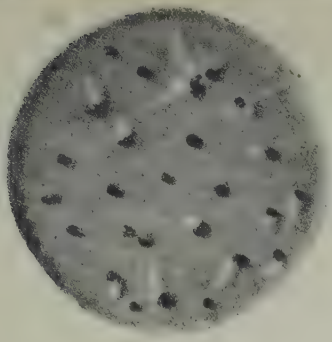
Figs. 8, 9, 10, and 11. Effect of temperature on the attack of *F. conglutinans* on cabbage. Fig. 8, plants from temperature control in cold-frame; fig. 9, plants from soil control in House IIc; fig. 10, plants from Flat No. 1 in House IIc; fig. 11, plants from Flat No. II in House IIc. Flats Nos. I and II and the temperature control all contained infected soil. Soil control was uninfected greenhouse soil. Madison, Wisconsin, April 11, 1914.

Fig. 12. Branched cabbage plant, one branch, *DE*, showing yellows, while other, *BC*, remains healthy. Platings made from marked points and results shown in fig. 13. Madison, Wisconsin, May 19, 1914.

Fig. 13. Plate made from plant shown in fig. 12. Note that pieces *B* and *C* from healthy branch remained sterile. Madison, Wisconsin, May 21, 1914.

Fig. 14. Stems of infected cabbage plant on potato hard agar. Note mycelial growth from vascular bundles and ends of cut stem. Madison, Wisconsin.

Figs. 15 and 16. Comparison of results of inoculation experiment. Fig. 15 shows three pieces of stem from each of three healthy cabbage plants grown in sterilized soil; fig. 16 shows the same from three diseased plants grown in soil that had been sterilized and inoculated with pure culture of *F. conglutinans*. Madison, Wisconsin, July 16, 1913.



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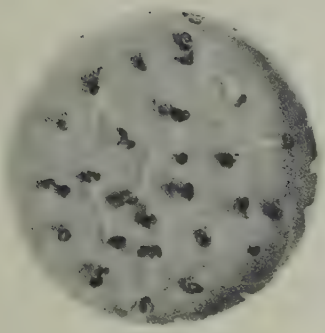

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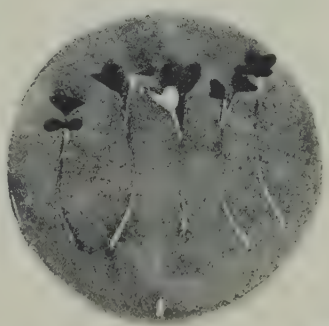

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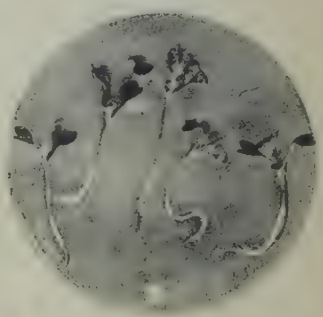

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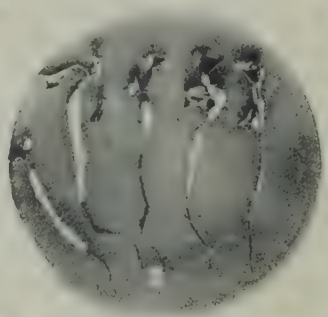

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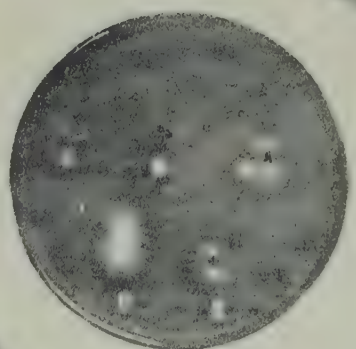

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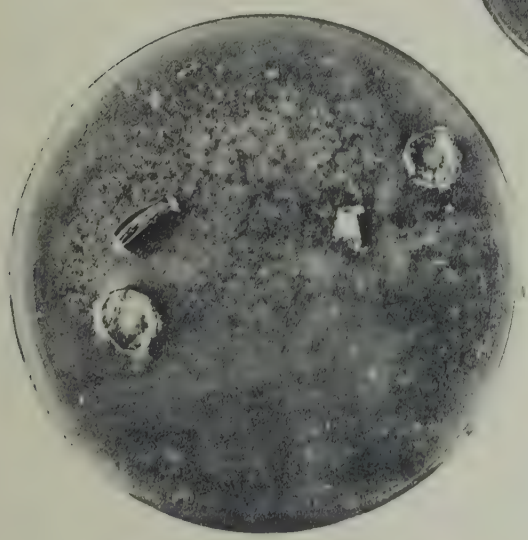

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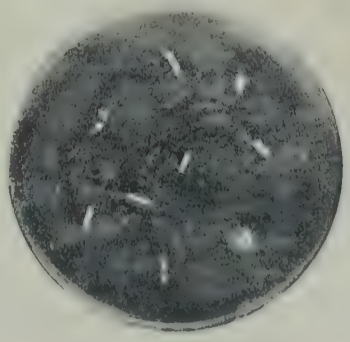

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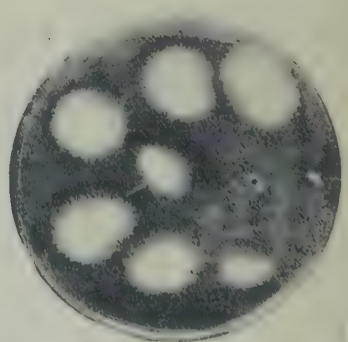

16

GILMAN—CABBAGE YELLOWS

MONOGRAPH OF THE NORTH AND CENTRAL AMERICAN SPECIES OF THE GENUS SENECIO—PART II[1]

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Sect. 6. Aurei Rydb.

§ 6. Aurei Rydb. Bull. Torr. Bot. Club **27**:173. 1900; Greenm. Monogr. Senecio, I. Teil, 22, 23, 29, 30. 1901, and in Engl. Bot. Jahrb. **32**:18, 19, 25, 26. 1902.

Herbaceous perennials, glabrous or in the early stages floccose-tomentose and more or less glabrate except in the axils of the leaves and occasionally at the base of the stem; stems erect or ascending, 1 to 10 dm. high, one to several from a common base or rootstock; leaves variable, the lowermost petiolate, rotund-ovate, oblong-ovate, obovate to narrowly oblanceolate, entire, crenate or dentate to more or less lyrate; stem-leaves petiolate to sessile, pinnatisect to entire, usually reduced towards the cymose inflorescence; heads radiate or discoid; achenes glabrous or hirtellous along the angles. Sp. 33–80.

Key to the Species

A. Stems 1 to 10 dm. high, erect or nearly so, simple or branched; heads one to many, discoid (except in *S. pauciflorus* var. *fallax*); achenes glabrous.

  a. Plants small, 1.5 dm. or less high; lower leaves subentire or sharply dentate.

    α. Lower leaves subentire..... *33. S. fedifolius*

    β. Lower leaves sharply dentate..... *34. S. Fernaldii*

  b. Plants larger, 1.5 to 10 dm. high; leaves thin in texture, the lower crenate-dentate.

[1]Issued July 7, 1916

Note.—The present paper is continued from Ann. Mo. Bot. Gard. 2:573–626. 1915.

α. Stem-leaves .5 to 3 cm. broad, usually with rather crowded divisions and narrow sinuses.

I. Heads discoid.

1. Lower leaves obovate..... *48a. S. obovatus* var. *elongatus*

2. Lower leaves ovate..... *35. S. pauciflorus*

II. Heads radiate ..... *35a. S. pauciflorus* var. *fallax*

β. Stem-leaves 1 to 6 cm. broad with remote divisions and deep rounded sinuses ..... *36. S. idahoensis*

c. Plants 1 to 6 dm. high; leaves thickish in texture, the lower entire, crenate to unequally lobate-dentate. ..... *37. S. debilis*

B. Stems erect or ascending, .5 to 4 dm. high, simple or branched; heads radiate, usually solitary; achenes glabrous or hirtellous.

a. Leaves mostly irregularly lobed or sublyrate.

α. Achenes hirtellous ..... *38. S. hyperborealis*

β. Achenes glabrous ..... *39. S. resedifolius*

b. Leaves mostly or all undivided.

α. Leaves thickish in texture; heads 8 to 14 mm. high.

I. Plants glabrous or nearly so..... *40. S. ovinus*

II. Plants white-tomentose at the base and in the leaf-axils.

1. Heads 12 to 14 mm. high; involucral bracts 21 ..... *41. S. conterminus*

2. Heads 8 to 10 mm. high; involucral bracts 13 ..... *42. S. hesperius*

β. Leaves thin in texture; heads 8 to 12 mm. high.

I. Plants of northern United States and Canada.

1. Lower leaves coarsely dentate. *43. S. Newcombei*

2. Lower leaves crenate-dentate. *44. S. subnudus*

II. Plants of Mexico..... *45. S. Rosei*

γ. Leaves reniform to oblong-obovate, thickish in texture; heads 14 to 20 mm. high.

I. Leaves reniform ..... *46. S. Porteri*

II. Leaves subrotund to oblong-obovate ..... *47. S. Soldanella*

C. Stems usually erect, 1.5 to 7 dm. high, simple or branched; heads commonly several to many, usually radiate (discoid in *S. obovatus* var. *elongatus*, *S. rubricaulis* var. *aphanactis* and rarely in *S. pauperculus*).

a. Leaves thin in texture, not succulent in the living state.

α. Basal leaves obovate, subrotund to oblong-elliptic, usually glabrous.... *48. S. obovatus*

β. Basal leaves rotund-ovate, oblong-ovate to oblong-lanceolate, cordate to abruptly narrowed at the base, glabrous or glabrate.

I. Lower leaves rotund-ovate, usually deeply cordate.

1. Heads few, 1 to 3..... *49. S. Cardamine*

2. Heads several to many.

* Plants of Mexico.

† Terminal segment of stem-leaves broader than long; achenes hispidulous ..... *50. S. cyclophyllus*

†† Terminal segment of stem-leaves not broader than long; achenes glabrous ... *51. S. quebradensis*

** Plants of western United States ..... *52. S. Pammelii*

*** Plants of eastern United States ..... *53. S. aureus*

II. Lower leaves ovate to oblong-lanceolate, shallowly cordate or abruptly narrowed at the base.

1. Margins of lower leaves crenate-dentate to doubly serrate.

* Lower leaves, at least some of them, shallowly cordate.

† Basal leaves oblong-lanceolate ..... *54. S. Robbinsii*

†† Basal leaves ovate.

‖ Margins of lower leaves finely serrate with incurved teeth. *55. S. pseudaureus*

‖‖ Margins of lower leaves more coarsely and more saliently toothed.

o. Bracteoles broad, obtuse... *35a. S. pauciflorus* var. *fallax*

oo. Bracteoles narrow, acute . *56. S. Burkei*

** Lower leaves abruptly cuneate at the base, not cordate.

† Eastern species.

‖ Upper leaves pinnately divided ..... *57. S. gaspensis*

||| Upper leaves incised-serrate ..... 58. *S. Crawfordii*

†† Western species.

|| Divisions of stem-leaves narrow ..... 59. *S. quaerens*

||| Divisions of stem-leaves broad ..... 60. *S. platylobus*

2. Margins of lower leaves entire or nearly so.

* Rays usually orange-red or saffron-colored ..... 61. *S. crocatus*

** Rays lemon-yellow.

† Stems closely cespitose ..... 62. *S. aquariensis*

†† Stems not closely cespitose.

|| Upper leaves conspicuously dilated into a broad amplexicaul base .... 63. *S. dimorphophyllus*

||| Upper leaves not conspicuously dilated into a broad amplexicaul base ... 64. *S. Farriae*

γ. Basal leaves oblong-ovate to lanceolate, often shallowly cordate; stems and leaves more or less persistently white-tomentulose, rarely glabrous.

I. Plants of the mountains of Arizona and New Mexico; achenes glabrous ..... 65. *S. Hartianus*

II. Plants of the low country and prairie throughout central United States; achenes usually hispidulous ..... 66. *S. plattensis*

δ. Basal leaves oblanceolate (except in *S. pauperculus* var. *firmifolius*), gradually narrowed at the base, glabrous or glabrate.

I. Plants subglaucous ..... 67. *S. Willingii*

II. Plants not at all glaucous.

1. Stems rather densely and permanently tomentose at the base; heads usually numerous. 68. *S. Smallii*

2. Stems but slightly tomentose at the base; heads comparatively few.

* Heads 5 to 9 mm. high; stems not flexuous.

† Eastern species ..... 69. *S. pauperculus*

†† Western species ..... 70. *S. flavovirens*

** Heads 10 to 13 mm. high; stems often flexuous ..... 71. *S. multnomensis*

b. Leaves usually thick or firm in texture, more or less succulent in the living state.

α. Lower leaves ovate to obovate, subentire to crenate-dentate.

I. Lower leaves broadly oval to elliptic-oblong, subentire to crenate-dentate.

1. Stems 2.5 to 5 dm. high..... *72. S. laetiflorus*

2. Stems usually lower, 1 to 2.5 dm. high ..... *73. S. Suksdorfii*

II. Lower leaves mostly obovate, entire to sharply dentate.

1. Lower leaves coarsely dentate. *74. S. rubricaulis*

2. Lower leaves entire or dentate towards the apex only..... *75. S. cymbalarioides*

β. Lower leaves mostly oblanceolate, entire or dentate chiefly towards the apex.

I. Plants 1 to 4 dm. high; cymes open, more or less flat-topped.

1. Stems tending to be leafy; leaves .5 to 2 cm. wide, achenes glabrous ..... *76. S. acutidens*

2. Stems not leafy; leaves narrower, .5–1 cm. wide; achenes hirtellous ..... *77. S. tridenticulatus*

II. Plants less than 1 dm. high; cymes close, somewhat rounded.. *78. S. Wardii*

γ. Lower leaves larger, ovate to oblanceolate, subentire to coarsely and saliently dentate with subcartilaginous teeth.

I. Leaves entire or only slightly dentate, somewhat glaucous; plants of the United States ..... *79. S. anacletus*

II. Leaves usually coarsely dentate, not glaucous; plants of Mexico. *80. S. toluccanus*

33. **S. fedifolius** Rydb. Bull. Torr. Bot. Club **27**:183, *pl. 5, fig. 7*. 1900, and Fl. Colo. 397. 1906; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

S. discoideus Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains 583. 1909, in part.

An herbaceous perennial; stem slender, 1.5 dm. high; basal leaves petiolate, blade ovate or broadly oval, 1 to 2 cm. long, entire or wavy margined; stem-leaves small, pinnately divided into short linear-oblong segments; heads 2 to 3, about 6 mm. high, discoid; involucral bracts commonly 13, lanceolate with membranous margins; achenes glabrous.

Distribution: mountains of Colorado.

Colorado: South Park, coll. of 1871, *Canby* (N. Y. College of Pharmacy Herb.), TYPE.

34. **S. Fernaldii** Greenm.[1]

A small herbaceous perennial, glabrous or slightly tomentose in the axils of the leaves, more or less purplish; stem erect, 1 dm. or less high, rising from an oblique rootstock; lower leaves petiolate, ovate to obovate-cuneate, including the petiole 1.5 to 3 cm. long, 1 to 1.5 cm. broad, sharply dentate; stem-leaves pinnatisect, the uppermost reduced to mere bracts; head solitary, discoid, 10 to 12 mm. high; involucre campanulate, calyculate; bracts of the involucre about 21, linear-lanceolate, 7 to 8 mm. long, a little shorter than the numerous flowers of the disk, purple; achenes glabrous.

Distribution: western Newfoundland.

Specimen examined:

Newfoundland: dry limestone barrens, upper slopes, and tablelands, Table Mountain, alt. 200–300 m., 16 Aug., 1910,

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[1]**Senecio Fernaldii** Greenm. sp. nov., herbaceus perennis glabrus vel in axillis foliorum parum tomentosus plus minusve purpurascens; caule erecto 1 dm. vel minus alto; foliis inferioribus petiolatis ovatis vel obovato-cuneatis petiolo incluso 1.5–3 cm. longis 1–1.5 cm. latis acute dentatis, superioribus pinnatisectis gradatim reductis; capitulo solitario 10–12 mm. alto discoideo; involucri squamis circiter 21 lineari-lanceolatis 7–8 mm. longis; flosculis disci numerosis; achaeniis glabris. —On dry limestone barrens, upper slopes, and tablelands of Table Mountain, Newfoundland, alt. 200 300 m., 16 Aug., 1910, *Fernald & Wiegand 4188* (Gray Herb., photograph in Mo. Bot. Gard. Herb.), TYPE.

Fernald & Wiegand 4188 (Gray Herb., photograph in Mo. Bot. Gard. Herb.), TYPE.

35. S. pauciflorus Pursh, Fl. Am. Sept. **2**:529. 1814, and ed. 2, 1816; Schlecht. in Linnaea **10**:90. 1836; DC. Prodr. **6**:431. 1837; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Piper, Contr. U. S. Nat. Herb. **11**:597. 1906; Piper & Beattie, Fl. Northwest Coast 387. 1915.

S. aureus δ. *discoideus* Hook. Fl. Bor. Am. **1**:333. 1834; Torr. & Gray, Fl. N. Am. **2**:442. 1843, in part.

S. aureus var. *borealis* Gray, Syn. Fl. N. Am. **1**:391. 1884, and ed. 2, 1886, in part, i. e., as to *S. pauciflorus* Pursh in synonymy.

S. Lemberti Greene, Pittonia **3**:89. 1896.

S. indecorus Greene, Fl. Franciscana 470. 1897.

S. aureus pauciflorus Britt. in Britton & Brown, Ill. Fl. **3**:480. 1898.

S. discoideus Britt. in Britton & Brown, Ill. Fl. **3**:479, *fig. 4042*. 1898, and ed. 2, **3**:544, *fig. 4626*. 1913.

S. elongatus Howell, Fl. Northwest Am. **1**:379. 1900, in part, not Pursh.

S. aureus Britt. in Britton & Brown, Ill. Fl. **3**:544. 1913, in part, i. e., as to *S. pauciflorus* Pursh in synonymy.

An herbaceous perennial, glabrous or with a white-floccose tomentum in the axils of the leaves and in the inflorescence; stems one to several from a common base, erect or ascending, 1 to 10 dm. high; lower leaves petiolate, ovate-rotund to ovate-oblong, 1 to 8 cm. long, 1 to 4.5 cm. broad, crenate-dentate, glabrous on both surfaces, their petioles equalling or twice exceeding the blade; stem-leaves sublyrate to pinnatisect, the uppermost sessile and much reduced; inflorescence a few to many-headed corymbose cyme; heads discoid, 10 to 12 mm. high; involucre campanulate, calyculate; bracts of the involucre usually about 21, linear-lanceolate, acute or acutish, more or less purplish; flowers numerous; achenes glabrous.

Distribution: usually in bogs and wet places, Labrador, eastern Quebec, northern Michigan, across the continent to the

Rocky Mountains, northwest to Alaska, and south to northern California.

Specimens examined:

Labrador: specimen from the Pursh herbarium, *ex Herb. Dickson* (Phil. Acad. Nat. Sci. Herb.); without locality, "*Leconte*" (Phil. Acad. Nat. Sci. Herb.); about Hokhak and Hebron, *fratres Morav.* (Gray Herb.); northern Labrador, Lat. 58°, coll. of 1873, *Anspach* (Mo. Bot. Gard. Herb.); wet crevices of rocks, Nachvak, 1 Aug., 1884, *Bell 14778* (Geol. Surv. Canada Herb.); Long Point, Aug., 1892, *Waghorne 4* (Geol. Surv. Canada Herb. and Mo. Bot. Gard. Herb.); Capstan Island, Aug., 1893, *Waghorne 9* (U. S. Nat. Herb.); near Forteau, coll. of 1894, *Waghorne 20* (Mo. Bot. Gard. Herb.); Rama, Lat. 58°50′, July, 1894, *Sornborger* (Gray Herb.); Rama, 20–24 Aug., 1897, *Sornborger 67* (Gray Herb. and U. S. Nat. Herb.); Rama, 15 July–20 Aug., 1897, *Stecker 67*[a] (Mo. Bot. Gard. Herb.); without locality, *Dr. Morrison* (Kew Herb.).

Quebec: Lake Petitsikapau, Hamilton River, 26 June, 1894, *Low 5104* (Geol. Surv. Canada Herb.); sandy shores of River Ste. Anne des Monts, Gaspé, 19 Aug., 1882, *Macoun 14808* (Geol. Surv. Canada Herb.); calcareous alpine meadow, Table-top Mountain, Gaspé Co., alt. 1000–1125 m., 7 Aug., 1906, *Fernald & Collins 261* (U. S. Nat. Herb.); on limestone conglomerate cliffs, peak west of Baptiste Michaud's, Bic, Rimouski Co., 16 July, 1904, *Collins & Fernald* (Gray Herb.); wet meadow, Bic, 22 July, 1910, *Williamson 1418* (C. S. Williamson Herb.); arbor-vitae swamps, Carleton, Bonaventure Co., 24–27 July, 1904, *Collins, Fernald & Pease* (Gray Herb.).

Ontario: wet gravelly places, Nipigon River, 2 July, 1884, *Macoun 14782* (Geol. Surv. Canada Herb.); bogs north of Port Arthur, 6 Aug., 1912, *Williamson 2148* (Phil. Acad. Nat. Sci. Herb.); Fort William, 24 July, 1912, *Williamson 1722* (Phil. Acad. Nat. Sci. Herb.); near Lake Superior, *Macoun 53* (Mo. Bot. Gard. Herb.).

Michigan: Keweenaw Peninsula, coll. of 1863, *Robbins 121* (Gray Herb.); Keweenaw Peninsula, July, 1890, and 7 July,

1915, *Farwell 776* (Gray Herb. and Mo. Bot. Gard. Herb.); Champion, July, 1889, *Hill* (Gray Herb.).

Rocky Mountains: "Grand saline, R. M. E. side," *Burke* (Gray Herb.).

Montana: Gallatin Valley, near Bozeman, alt. 1615 m., 7 July, 1896, *Flodman 908* (Mo. Bot. Gard. Herb., Greene Herb., and U. S. Nat. Herb.); wet shady places, Gallatin River, 14 July, 1905, *Blankenship 292* (Mo. Bot. Gard. Herb., Phil. Acad. Nat. Sci. Herb., Field Mus. Herb., and U. S. Nat. Herb.).

Wyoming: Little Goose Cañon, Sheridan Co., 1 July, 1901, *Nelson 2383* (Mo. Bot. Gard. Herb.); Middle Ten Sleep Creek, Big Horn Co., 1 Aug., 1901, *Goodding 465* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.).

Idaho: Forks of St. Mary's River, alt 1100 m., 3 July, 1895, *Leiberg 1158* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Alberta: below Pipestone Summit, Rocky Mountain Park, 6 July, 1904, *Macoun 65018* (Gray Herb. and Geol. Surv. Canada Herb.); Blind Valley and Lakes, alt. 2130–2440 m., 6 July, 1906, *Brown 414* (Phil. Acad. Nat. Sci. Herb.); head of Snake River, 5 Aug., 1911, *Riley 32* (U. S. Nat. Herb.).

Mackenzie: Fort Franklin, Mackenzie River, *Richardson* (Geol. Surv. Canada Herb., photograph in Field Mus. Herb. and in Mo. Bot. Gard. Herb.), part of TYPE of *S. aureus* var. *discoideus* Hook.

Yukon: Ft. Selkirk, 18 July, 1899, *Tarleton 134* (U. S. Nat. Herb.); vicinity of Summit and Middle Lakes, coll. of 1898, *Bolton* (U. S. Nat. Herb.); moist glades, Red Mountain, 17 July, 1899, *Gorman 1114* (U. S. Nat. Herb.); Moosehide Mountain, Dawson, 14 July, 1902, *Macoun 78974* (Field Mus. Herb.); damp woods, West Dawson, 16 July, 1902, *Macoun 78975* (Field Mus. Herb.); Finlayson River, Lat. 61°N., *Dawson 14776* (Geol. Surv. Canada Herb.).

Alaska: south bank of Forty Mile Creek, Yukon River, 13 July, 1893, *Funston 126* (U. S. Nat. Herb.); near Knik, Oct., 1913, *Chaney* (Mo. Bot. Gard. Herb.); Kenai, 18–20 Aug., 1904, *Piper 4216* (U. S. Nat. Herb.).

British Columbia: Moose Lake, 14–24 Aug., 1911, *Riley 22* (U. S. Nat. Herb.); Kicking Horse Lake, alt. 1675 m., 15 Aug., 1890, *Macoun 14771* (Geol. Surv. Canada Herb.); Kicking Horse Valley, near Field, alt. 1230 m., 20 June–25 July, 1906, *Brown 487*[a] (Phil. Acad. Nat. Sci. Herb.); Ottertail Drive, near Field, July, 1905, *Farr 814, 820* (Univ. Penn. Herb. and Field Mus. Herb.); Wapta Lake, 4 Aug., 1904, *Macoun 65019, 65020* (Gray Herb. and Geol. Surv. Canada Herb.); Carbonate, alt. 825 m., 7 July, 1904, *Heacock 185* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Upper Spillmacheen Valley, alt. 1980 m., 3 Aug., 1904, *Petersen 440* (Gray Herb., U. S. Nat. Herb., Mo. Bot. Gard. Herb., and Phil. Acad. Nat. Sci. Herb.); Cornwall Hills, 28 July, 1894, *McCoy 5100* (Gray Herb. and Geol. Surv. Canada Herb.); Skagit Valley, 28 June, 1905, *Macoun 69360* (Gray Herb.); Maclennan River, branch of Columbia River, 31 July, 1898, *Spreadborough 19727* (Geol. Surv. Canada Herb. and Greene Herb.); Chilliwack Valley, 22 June, 1901, *Macoun 26683* (Gray Herb., Geol. Surv. Canada Herb., and Mo. Bot. Gard. Herb.), *26684* and *26685* in part (Gray Herb. and Geol. Surv. Canada Herb.); alpine rivulet, Goldstream, alt. 1675 m., 25 July, 1905, *Shaw 1012* (U. S. Nat. Herb.); Alberni, Arrowsmith Trail, Vancouver Island, 27 June, 1907, *Rosendahl 1971* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Wolf Creek, Strathcona Park, Vancouver Island, 10 Aug., 1912, *Macoun 83192* (Geol. Surv. Canada Herb. and Mo. Bot. Gard. Herb.); Kasaan Mountain, Queen Charlotte Island, 7 July, 1901–02, *Newcombe 69* (Field Mus. Herb.).

Washington: Deming, Whatcom Co., 30 June, 1898, *Flett 852* in part (Piper Herb.); Big Meadows, six miles west of Ione, 6 Aug., 1902, *Kreager 428* (Gray Herb., U. S. Nat. Herb., and Piper Herb.); Mt. Constitution, Dreas Island, Aug., 1892, *Henderson 2312* (Gray Herb.).

California: Truckee, 16 June, 1901, *Williamson* (C. S. Williamson Herb.); Mt. Dana, coll. of 1866, *Bolander 6021* (Field Mus. Herb.) and *6021* in part (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Lassens Peak, July, 1896, *Austin 365* (U. S. Nat.

Herb. and Mo. Bot. Gard. Herb.); Pine Creek, Lassen Co., 9 July, 1894, *Baker & Nutting* (Greene Herb.), TYPE of *S. indecorus;* Sierra Co., coll. of 1874, *Lemmon 127* (Mo. Bot. Gard. Herb.); Sierra Nevada Mountains, coll. of 1875, *Lemmon* (U. S. Nat. Herb. 48716); Soda Springs, Tuolumne Co., July, 1894, *Lembert 171* (Gray Herb.); Yosemite Region, coll. of 1893, *Lembert* (Gray Herb. and Greene Herb. in part); Soda Springs, Mt. Conness, 6 Aug., 1890, *Harford* (Greene Herb.), TYPE of *S. Lemberti.*

To this species are also to be referred two specimens without record of locality, namely, one from the collection of Nuttall, presented by Elias Durand, 1866 (Gray Herb.), and one from the Bernhardi collection (Mo. Bot. Gard. Herb.).

Var. **fallax** Greenm. Contr. U. S. Nat. Herb. **11**:597. 1906, and in Piper & Beattie, Fl. Northwest Coast 388. 1915.

Similar in stature and in foliage to the species; heads radiate; ray-flowers 10 to 12, rays yellow; disk-flowers 50 to 60; achenes glabrous.

Distribution: occurring occasionally with the species.

Specimens examined:

Ontario: Silver Islet Beach, 4 Aug., 1914, *Williamson 2075* (C. S. Williamson Herb.); Port Arthur, 6 Aug., 1914, *Williamson 2148* (C. S. Williamson Herb.).

Michigan: Mainland Park Harbor, Isle Royal, 15–16 Aug., 1912, *Williamson 2312* (Phil. Acad. Nat. Sci. Herb.).

Alaska: along the Yukon River, near Ft. Yukon, coll. of 1881, *Bates* (U. S. Nat. Herb. 48813, 48814, and Greene Herb.).

Washington: Deming, Whatcom Co., 30 June, 1898, *Flett 852* in part (Piper Herb.).

California: Mt. Dana, coll. of 1866, *Bolander 6021* in part (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Yosemite Region, coll. of 1895, *Lembert* (Gray Herb. and U. S. Nat. Herb.); Mt. Goddard, alt. 3050 m., *Hall & Chandler 660* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); along the North Fork of Kern River, Sierra Nevada, 25 Aug., 1891, *Coville & Funston 1708* (U. S. Nat. Herb.).

36. S. idahoensis Rydb. Bull. Torr. Bot. Club **27**:183, *pl. 6, fig. 5.* 1900; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

A rather stout herbaceous perennial, 4 to 7 dm. high, glabrous or slightly white floccose-tomentulose in the axils of the leaves; stem branched from near the base, rather leafy in the lower portion, nearly naked towards the inflorescence, stramineous to somewhat purplish; leaves 2.5 to 14 cm. long, 1 to 6 cm. broad, mostly pinnately parted into oblong or somewhat cuneate subincised divisions with broad and deep rounded sinuses; inflorescence terminating the stem and branches in a several to many-headed corymbose cyme; heads discoid, 10 to 12 mm. high; involucre campanulate, calyculate; bracts of the involucre commonly 21, linear-lanceolate, 7 to 9 mm. long, acutish, more or less purplish-tipped; flowers numerous; achenes glabrous.

Distribution: Idaho, northwest into British Columbia.

Specimens examined:

Idaho: in meadows at Granite Station, Kootenai Co., 30 Aug., 1892, *Sandberg, MacDougal & Heller 803* (Gray Herb. and Phil. Acad. Nat. Sci. Herb.), CO-TYPE.

British Columbia: Griffin Lake, 6 July, 1889, *Macoun,* without number (Gray Herb.).

A species very near the preceding from which, however, it differs in the branching of the stem and by the large broad stem-leaves with cut divisions and deep rounded sinuses.

37. S. debilis Nutt. in Trans. Am. Phil. Soc. **7**:408. 1841; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Blankenship in Mont. Agr. Coll. Sci. Studies **1**:102. 1904.

S. aureus var. *discoideus* Torr. & Gray, Fl. N. Am. **2**:442. 1843, in part, i. e., as to *S. debilis* Nutt. in synonymy.

S. aureus var. *borealis* Gray, Syn. Fl. N. Am. 1^2:391. 1884, and ed. 2, 1886, in part.

S. flavovirens Rydb. Bull. Torr. Bot. Club **27**:181. 1900, in part, as to plant of Greene.

S. nephrophyllus Rydb. Mem. N. Y. Bot. Gard. **1**:446. 1900, and in Bull. Torr. Bot. Club **27**:183. 1900.

S. discoideus Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains 583. 1909, in part, not *S. aureus* var. *discoideus* Hook.

An erect herbaceous perennial, glabrous throughout or slightly floccose-tomentulose in the axils of the leaves and along the midrib on the upper surface of the young leaves; stems 1 to 5 dm. high; leaves thickish in texture; basal leaves petiolate, subreniform to ovate-oblong, 1 to 6 cm. long, 1 to 4 cm. broad, entire, crenately and unequally lobate-dentate; petioles variable in length from 1.5 cm. to nearly 2 dm. long; stem-leaves petiolate or sessile, sublyrate to pinnately divided into remote linear-oblong or subcuneate obtusish, often unequal, divisions and deep rounded sinuses; inflorescence terminating the stem in a few to several-headed corymbose cyme; heads 7 to 10 mm. high, discoid; flowers numerous; achenes glabrous.

Distribution: Montana and Colorado, west to Idaho and Oregon.

Specimens examined:

Montana: meadows, Big Blackfoot River, 13 July, 1883, *Canby 34* (Gray Herb.), and *203* (Phil. Acad. Nat. Sci. Herb.); Melrose, 6 July, 1895, *Shear 5011* (U. S. Nat. Herb.).

Wyoming: Laramie Plains, alt. 2590 m., 20 July, 1884, *Sheldon 73* (U. S. Nat. Herb.); Laramie, 28 July, 1889, *Greene* (U. S. Nat. Herb. and Field Mus. Herb.); Laramie hills, 17 July, 1897, *Nelson 3404* (Mont. Agr. Coll. Herb.); Laramie Plains, 21 July, 1898, *Osterhout* (Field Mus. Herb.); wet banks, City Springs, Laramie, 8 Aug., 1901, *Nelson 8599* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Laramie River, along the Medicine Bow Mountains, coll. of 1856, *H. Engelmann* (Gray Herb. and Mo. Bot. Gard. Herb.); wet meadows, Centennial, 27 July, 1900, *Nelson 7722* (Mo. Bot. Gard. Herb.); boggy draws, Centennial, 27 July, 1902, *Nelson 8685* (Gray Herb., U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); Wind River bottom, 28 July,

1882, *Forwood* (Gray Herb. and U. S. Nat. Herb.); Meadow Creek, 9 Aug., 1894, *Nelson 906* (Gray Herb. and Greene Herb.); Bridger's Pass, coll. of 1856, *H. Engelmann* (Gray Herb.); Soldier Springs, Aug., 1891, *Nelson 177* (U. S. Nat. Herb.).

Colorado: Rocky Mountains, coll. of 1861, *Parry 19* (Phil. Acad. Nat. Sci. Herb.); Rocky Mountains, Lat. 39°41′, coll. of 1862, *Hall & Harbour 332* in part (Mo. Bot. Gard. Herb. and Gray Herb.); Lake John, 19 Aug., 1898, *Shear & Bessey 3990* (U. S. Nat. Herb.); near High, 19 Aug., 1898, *Shear & Bessey 4005* (U. S. Nat. Herb.).

Idaho: grassy bog, One Thousand Springs Valley, alt. 2040 m., 7 Aug., 1895, *Henderson 3671* (U. S. Nat. Herb.).

Oregon: "Plains of the Oregon, near the Wahlamet," *Nuttall* (Gray Herb.), TYPE.

38. S. hyperborealis Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Ann. Mo. Bot. Gard. **1**:264. 1914.

S. resedifolius Hook. Fl. Bor. Am. **1**:333, *pl. 117*. 1834, in part, not Less.; DC. Prodr. **6**:347. 1837, in part; Torr. & Gray, Fl. N. Am. **2**:445. 1843, in part; Gray, Syn. Fl. N. Am. **1**^{2}:390. 1884, and ed. 2, 1886, in part; Macoun, Cat. Canadian Pl. 267. 1884, in part, i. e., as to plant of Richardson.

Stems erect or nearly so, one to several from a perennial base, 1 to 2 dm. high, simple or branched, white-tomentose at the base and in the leaf-axils; lower leaves obovate and crenately margined to sublyrate or pinnately divided with rather remote obtusely dentate divisions, including the petiole 4 to 10 cm. long, 1 to 2.5 cm. broad; stem-leaves sessile, more or less pinnatisect, the uppermost reduced to lance-attenuate entire bracts; heads solitary or few terminating the stem and branches, 8 to 12 mm. high, radiate; involucre campanulate, sparingly calyculate, glabrous; bracts of the involucre about 13, lanceolate, acute, 5 to 6 mm. long; ray-flowers 10 to 12, rays yellow; disk-flowers rather numerous; achenes hirtellous-puberulent along the angles.

Distribution: Arctic northwest America.

Specimens examined:

Mackenzie: "on limestone at the mouth of the Bear Lake River, and about Fort Norman and Fort Franklin," *Richardson* (Gray Herb. ex Hooker, Torrey Herb., and Geol. Surv. Canada Herb. 14872 in part), CO-TYPE; west shore of Great Bear Lake, June–Aug., 1900, *Bell 22937* (Geol. Surv. Canada Herb.).

39. S. resedifolius Less. in Linnaea **6**:243. 1831; Ledeb. Fl. Rossica **2**:631. 1844–46, in major part; DC. Prodr. **6**:347. 1837, in major part; Torr. & Gray, Fl. N. Am. **2**:445. 1843, in part; Gray, Syn. Fl. N. Am. 1^2:390. 1884, and ed. 2, 1886, in part; Macoun, Cat. Canadian Pl. 267. 1884, in part; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

Cineraria lyrata Ledeb. in Mem. Acad. Petersb. **5**:576. 1818; Reichb. Ic. Bot. **2**:1, *pl. 101.* 1824; Hook. & Arn. Bot. Beechey's Voy. 126. 1832.

A low herb; stems one to several from a perennial base, simple or branched, .5 to 2 dm. high, glabrous or slightly tomentose, particularly in the axils of the leaves; lower leaves petiolate, rotund-ovate, sublyrate or irregularly pinnately divided, crenate to sharply dentate; upper stem-leaves sessile, more or less pinnatisect, often reduced to lance-attenuate entire bracts; heads solitary or few, radiate, about 1 cm. high, including the rays 2 to 2.5 cm. in diameter; bracts of the calyculate involucre linear-lanceolate, 6 to 8 mm. long, acuminate, acute, often purplish; achenes glabrous.

Distribution: Alaska and Siberia.

Specimens examined:

Alaska: St. Lawrence Island, *Chamisso* (Gray Herb., Berlin Herb., and Kew Herb.); Behring Strait, U. S. North Pacific Exploring Expedition, 1853–56, *Wright* (Gray Herb.); Hall Island, Behring Sea, coll. of 1885, *Thompson* (Field Mus. Herb.); Hall Island, Behring Sea, 11 Aug., 1891, *Macoun 20640* (Geol. Surv. Canada Herb.); Herschel Island, Arctic Sea, coll. of 1893, *Stringer 14390* (Geol. Surv. Canada Herb.); Port Clarence, 21 July, 1895, *Sharp* (Phil. Acad. Nat. Sci. Herb.);

Cape Nome, coll. of 1890, *Blaisdell* (Gray Herb.); vicinity of Nome, *Powers 6* (Field Mus. Herb.); Cape Vancouver, 9 Aug., 1891, *Macoun* (Geol. Surv. Canada Herb., Gray Herb., and Mo. Bot. Gard. Herb.); Kuskokwim Valley, coll. of 1884, *Weimmann* (Gray Herb.), branched form; Unga and Shumagin Islands, U. S. Coast Survey, 1871–72, *Harrington* (Gray Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.).

Var. **columbiensis** Gray, Syn. Fl. N. Am. 1²:390. 1884, and ed. 2, 1886; Macoun, Cat. Canadian Pl. 267. 1884.

S. hyperborealis var. *columbiensis* (Gray) Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Ann. Mo. Bot. Gard. **1**:264. 1914.

Stems about 2 dm. high, one to several from a common base; heads subdiscoid, namely, with inconspicuous ray-flowers shorter than the bracts of the involucre.

Distribution: British Columbia.

Specimen examined:

British Columbia: Mucklung River, 25 July, 1882, *Mackay* (Gray Herb.), TYPE.

40. S. ovinus Greene, Pittonia **4**:110. 1900; Blankenship, Mont. Agr. Coll. Sci. Studies **1**:103. 1904.

S. resedifolius Rydb. Mem. N. Y. Bot. Gard. **1**:447. 1900, not Less.

A low herbaceous perennial, glabrous or somewhat tawny, floccose-tomentulose in the axils of the leaves; stems one to several from an ascending stoutish rootstock, .5 to 2 dm. high, erect or nearly so; lower leaves broadly ovate to obovate, occasionally sublyrate, including the petiole 1 to 6 cm. long, the blade .5 to 3 cm. long, .3 to 2.5 cm. broad, subentire to crenate-dentate, glabrous, thickish in texture; upper leaves sessile, laciniate to entire; heads usually solitary, occasionally two, 8 to 10 mm. high, radiate; involucre companulate, sparingly calyculate; bracts of the involucre about 21, linear-lanceolate, acuminate, acute, 7 to 8 mm. long, often purplish; ray-flowers 13 to 21, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: mountains of Alberta to Wyoming.

Specimens examined:

Alberta: high slopes of Sheep Mountain, Waterton Lake, 29 July, 1895, *Macoun 11619* (Geol. Surv. Canada Herb., Gray Herb., photograph in Field Mus. Herb. and Mo. Bot. Gard. Herb.), TYPE.

British Columbia: near the western summit of North Kootenai Pass, 26 July, 1883, *Dawson* (Geol. Surv. Canada Herb. 14826 in part, and Greene Herb.).

Montana: McDonalds Peak, Mission Range, alt. 2440 m., 19 July, 1883, *Canby 36* (Gray Herb.); Stanton Lake, 1 Aug., 1894, *Williams 1022* (Gray Herb., U. S. Nat. Herb., and Mont. Agr. Coll. Herb.); Mt. Hyalite, alt. 3000 m., 1 Aug., 1902, *Blankenship* (Gray Herb.); Sperry Glacier, 1 Sept., 1903, *Umbach 798* (Field Mus. Herb.); Sperry Glacier, alt. 2440 m., 1 Sept., 1903, *Blankenship* (Gray Herb.); MacDougal Park, Flathead Lake and vicinity, 31 July, 1908, *Clemens* (Field Mus. Herb. and Mo. Bot. Gard. Herb.); Glacier National Park, 11 July, 1914, *Hitchcock 11962* (U. S, Nat. Herb.).

Wyoming: Wind River Mountains, alt. 2700–3000 m., "*C.R.*" (Gray Herb.).

41. S. conterminus Greenm. nom. nov.

S. Lyallii Klatt in Annal. Naturhist. Hofm. Wein **9**:365. 1894, not Hook. f.; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

A low depressed somewhat cespitose herbaceous perennial, conspicuously white-floccose tomentose at the base and in the axils of the leaves; stems erect or nearly so, 4 to 8 cm. high from a stout rootstock; leaves thickish, the lower ovate-rotund to oblong-spatulate or occasionally sublyrate, crenate-dentate to obtusely lobed, including the petiole 1 to 3 cm. long, 1 cm. or less broad; stem-leaves sessile, laciniate, the uppermost reduced to entire purplish-tipped bracts; heads usually solitary, 10 to 14 mm. high, radiate; involucre campanulate, calyculate, floccose-tomentulose at the base, glabrous above; bracts of the involucre about 21, linear-lanceolate, acuminate, 8 to 10 mm. long, somewhat penicillate, and more or less tinged with purple; ray-flowers 10 to 12, rays yellow; disk-flowers numerous, slightly exceeding the involucre; achenes glabrous.

Distribution: Rocky Mountains, near the Canadian boundary, northward into Alberta and British Columbia.

Specimens examined:

Rocky Mountain summits, alt. 2130–2440 m., Oregon Boundary Commission, coll. of 1861, *Lyall* (Gray Herb., Kew Herb., and Berlin Herb.), TYPE.

Alberta: Sheep Mountain, Waterton Lake, 28–31 July, 1895, *Macoun* (Kew Herb., Berlin Herb., and U. S. Nat. Herb. 289213); on the summit of Moose Mountain, alt. 2285 m., 29 June–1 July, 1897, *Macoun 22781, 22773* (Geol. Surv. Canada Herb.); on high mountain slopes, Crows Nest Pass, alt. 1825–2285 m., 2 Aug., 1897, *Macoun 22782, 22783* in part (Geol. Surv. Canada Herb.).

British Columbia: north summit of North Kootenai Pass, coll. of 26 July, 1883, *Dawson* (Geol. Surv. Canada Herb. 14826 in part).

42. S. hesperius Greene, Pittonia **2**:166. 1891. Pl. 3, fig. 1.

S. hesperis Howell, Fl. Northwest Am. **1**:375. 1900.

S. pyroloides Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

S. auleticus Greene, Leafl. Bot. Obs. & Crit. **2**:15. 1909.

A slender herbaceous perennial; stem erect, 1 to 2 dm. high, floccose-tomentulose, especially at the base and in the axils of the leaves, later more or less glabrate, obovate-rotund to oblanceolate, including the petiole 1 to 6 cm. long, .5 to 1.8 cm. broad, entire to crenate-dentate, narrowed at the base into a petiole equalling or much exceeding the blade, at first tomentulose soon glabrate; stem-leaves sessile, laciniate to linear-attenuate; heads usually solitary, occasionally two, rarely five, 10 to 12 mm. high, radiate; involucre campanulate, sparingly calyculate, slightly tomentulose to glabrous; bracts of the involucre 13 to 21, linear-lanceolate, 5 to 8 mm. long; rays yellow; disk-flowers rather numerous; achenes glabrous.

Distribution: southwestern Oregon.

Specimens examined:

Oregon: Eight Dollar Mountain, May, 1884, *Howell 160* (Gray Herb.); near Kirbyville, 27 May, 1884, *Howell 1511*

(Greene Herb., U. S. Nat. Herb., Torrey Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb), TYPE; Eight Dollar Mountain, 13 June, 1904, *Piper 6145* (U. S. Nat. Herb.); eight miles south of Waldo, 14 June, 1904, *Piper 6254* (U. S. Nat. Herb.).

43. S. Newcombei Greene, Pittonia **3**:249. 1897.

A slender herbaceous perennial, glabrous throughout; stem solitary, erect or nearly so, 1.5 to 2 dm high; leaves thin, the lower petiolate, reniform to obovate in general outline, 3 to 7-lobate-dentate, 1 to 1.5 cm. long, 1 to 2 cm. broad, subcordate to abruptly narrowed at the base into a slender petiole, the lobes ovate-oblong, mucronate; upper leaves cuneate to linear; heads solitary, radiate, about 1 cm. high; involucre subcampanulate, ecalyculate, glabrous; bracts of the involucre 8 to 13, lanceolate, 6 to 8 mm. long, acute; ray-flowers 10 to 12, rays narrowly oblong, 1 to 1.5 cm. long, 2 to 4 mm. broad, in the dried state more or less tinged with lilac; disk-flowers rather numerous; achenes striate, glabrous.

Distribution: known only from Queen Charlotte Islands.

Specimens examined:

British Columbia: Kaitgoro, west coast of Moresby Island, Queen Charlotte Islands, 28 June, 1897, *Newcombe* (Greene Herb., Geol. Surv. Canada Herb. 18707, and Kew Herb., tracing in Gray Herb.), TYPE; in the same locality, coll. of 1903, *Newcombe* (Field Mus. Herb. and Gray Herb.).

This species is known only from its original station, and while it exhibits certain characteristics not common in *Senecio*, yet it has the technical floral characters of this genus.

44. S. subnudus DC. Prodr. **6**:428. 1837; Nutt. in Trans. Am. Phil. Soc. **7**:412. 1841; Torr. & Gray, Fl. N. Am. **2**:445. 1843; Howell, Fl. Northwest Am. 378. 1900; Rydb. Mem. N. Y. Bot. Gard. **1**:447. 1900, and Bull. Torr. Bot. Club **27**:184. 1900; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Piper, Contr. U. S. Nat. Herb. **11**:597. 1906; Coulter & Nelson, Manual Cent. Rocky Mountains 582. 1909.

S. aureus var. *subnudus* Gray, Syn. Fl. N. Am. 1^2:391. 1884, and ed. 2, 1886; Macoun, Cat. Canadian Pl. 266. 1884.

S. cymbalarioides Buek, Ind. DC. Prodr. pt. 2, p. vi. 1840, not Nutt.

A slender herbaceous perennial, glabrous throughout; stem simple, erect, 1 to 3.5 dm. high, rising from a slender rootstock; leaves thin, membranous, the lower petiolate, subrotund-obovate, occasionally sublyrate, including the petiole .5 to 9 cm. long, .5 to 3 cm. broad, abruptly to gradually narrowed at the base, crenate-dentate; the upper leaves sessile, incised to entire; heads solitary or occasionally two, 8 to 10 mm. high, including the yellow rays 1.5 to 2.5 cm. in diameter; bracts of the involucre about 21, linear-lanceolate, acute, glabrous and often purplish, slightly shorter than the rather numerous flowers of the disk; achenes glabrous.

Distribution: Montana and Wyoming to Washington and California.

Specimens examined:

Montana: bogs, Park Co., alt. 2800 m., Aug., 1897, *Tweedy 344* (Mont. Agr. Coll. Herb.); in open bogs among the hills, West De Lacy Creek, 4 Aug., 1899, *A. & E. Nelson 6300* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Old Hollowtop, near Pony, alt. 2740 m., 7 July, 1897, *Rydberg & Bessey 5270* (Gray Herb., U. S. Nat. Herb., Field Mus. Herb., and Mont. Agr. Coll. Herb.).

Yellowstone National Park: Upper Falls of the Yellowstone, Hayden's U. S. Geol. Survey, 1871, *Adams* (U. S. Nat. Herb.); in bogs, alt. 2740 m., Aug., 1885, *Tweedy 720* (U. S. Nat. Herb. 143107, and Field Mus. Herb.).

Rocky Mountains: Lat. 49° N., alt. 1980 m., Oregon Boundary Commission, 1861, *Lyall* (Gray Herb.).

Wyoming: without definite locality or date of collection, *Tweedy 585* (U. S. Nat. Herb. 48711); Wind River Chain of Rocky Mountains, alt. 2135 m., *Fremont* (Gray Herb.).

Idaho: ridges south from Wiessner's Peak, alt. 1900 m., 27 July, 1895, *Leiberg 1376* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Bear Creek Cañon, alt. 1500 m., 1 Sept., 1897, *Leiberg 2968* (U. S. Nat. Herb.).

Washington: Horse Shoe Basin, Okanogan Co., Sept., 1897, *Elmer 1423* (Mo. Bot. Gard. Herb.); Yakima region.

Northern Transcontinental Survey, coll. of 1882, *Brandegee 118* (Mo. Bot. Gard. Herb.) and *915* (Gray Herb.); wet meadows, Chiquash Mountains, Skamania Co., 18 Aug., 1892, *Suksdorf 2167* (Gray Herb., U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); north of Mt. Adams, Aug., 1892, *Henderson 2308* (Gray Herb.); wet meadows, alt. about 2000 m., Mt. Paddo (Adams), 3 Sept., 1904, *Suksdorf 4241* (U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.).

Oregon: Eagle Creek Mountains, Union Co., alt. 2440 m., Aug., 1881, *Cusick 938, 959* (Gray Herb.); wet meadows of the highest mountains, eastern Oregon, coll. of 1897, *Cusick 1804* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); granitic soil, swampy meadows, North Catherin Creek, eastern Oregon, alt. 1500 m., 26 July, 1907, *Cusick 3177* (U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); sedgy meadow, Wallowa Mountains, source of Kettle Creek, alt. 2285 m., 12 Aug., 1909, *Cusick 3379* (U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); "Cascade Mountains on the Oregon" *(Douglas?) Dr. Gairdner* (Gray Herb.); without locality, coll. of 1871, *Hall 304* (Gray Herb. and Mo. Bot. Gard. Herb.); base of Mt. Hood, June, 1878, *J. & S. J. Howell* (Field Mus. Herb.); Mt. Hood, alt. 1220 m., 25–26 Aug., 1914, *Hitchcock 12328* (U. S. Nat. Herb.); Cascade Mountains, Aug., 1880, *Howell* (U. S. Nat. Herb. 48811, and Field Mus. Herb.).

California: Plumas Co., coll. of 1876, *Mrs. Austin* (Gray Herb. and Field Mus. Herb.); summit of Mt. Dana, coll. of 1878, *Lemmon* (Gray Herb.); Pine Creek, July, 1912, *Baker* (Field Mus. Herb.).

45. S. Rosei Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Field Col. Mus. Bot. Ser. **2**:276. 1907. Pl. 3, fig. 2.

An herbaceous perennial; stem solitary, erect, 4 to 4.5 dm. high, simple, glabrous below, slightly pubescent above, terminated by a single large radiate head; lower leaves petiolate, ovate, 2 to 3 cm. long, two-thirds as broad, obtuse, subentire to crenate-dentate, thin, glabrous on both surfaces; petioles

2.5 to 8 cm. long; upper stem-leaves sublaciniate and somewhat ampliated at the base and partly clasping the stem; heads about 12 mm. high, including the rays 3 to 3.5 cm. in diameter; involucre campanulate, essentially ecalyculate; bracts of the involucre lanceolate-linear, 8 to 10 mm. long, acute, glabrous; ray-flowers 10 to 12, rays light yellow, conspicuous; disk-flowers numerous; achenes glabrous.

Distribution: west central Mexico.

Specimen examined:

Territory of Tepic: Sierra Madre, near Santa Teresa, 10 Aug., 1897, *Rose 2157* (Gray Herb. and U. S. Nat. Herb.), TYPE.

46. S. Porteri Greene, Pittonia **3**:186. 1897; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Rydb. Fl. Colo. 397. 1906.

S. renifolius Porter in Porter & Coulter, Syn. Fl. Colo. 83. 1874, not Schz. Bip.; Gray, Syn. Fl. N. Am. 1^2:389. 1884, and ed. 2, 1886; Coulter, Manual Rocky Mountain Region 210. 1885.

A low herbaceous perennial, glabrous throughout and more or less tinged with purple; stems ascending from a slender rootstock, 1 dm. or less high; leaves petiolate, mostly reniform, including the petiole 1.5 to 5 cm. long, .8 to 2.5 cm. broad, crenate; heads about 14 mm. high, solitary on nearly naked peduncles, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre about 13, linear-lanceolate, acute, 10 mm. long, purplish; ray-flowers 8 to 10, rays bright yellow; disk-flowers numerous; achenes glabrous.

Distribution: high mountains of Colorado and eastern Oregon.

Specimens examined:

Colorado: White House Mountain, alt. 3960 m., Hayden's U. S. Geol. Survey, 9 Aug., 1873, *Coulter 2950* (Gray Herb., Phil. Acad. Nat. Sci. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.).

Oregon: alpine ridges of the Wallowa Mountains, 3 Aug., 1899, *Cusick 2308* (Gray Herb., Kew Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.).

47. **S. Soldanella** Gray, Proc. Acad. Nat. Sci. Phil. **15**:67. 1863; Porter & Coulter, Syn. Fl. Colo. 83. 1874; Gray, Syn. Fl. N. Am. 1^2:384. 1884, and ed. 2, 1886; Coulter, Manual Rocky Mountain Region 206. 1885; Rydb. Fl. Colo. 394. 1906; Coulter & Nelson, Manual Cent. Rocky Mountains 578. 1909; Clements & Clements, Rocky Mountain Fls. 291. 1914.

S. Grayi Parry ex Gray, Proc. Acad. Nat. Sci. Phil. **15**:67. 1863, not *S. Greyi* Hook. f.

A low herbaceous perennial, 1 to 2 dm. high, glabrous throughout and more or less tinged with purple; stems flexuous, ascending from a stoutish rootstock, the latter bearing numerous fleshy-fibrous roots; leaves somewhat succulent, subrotund to oblong-obovate, 1.5 to 5.5 cm. broad, entire to sinuate-dentate, subcordate or more frequently cuneate at the base into a winged petiole much exceeding the blade; heads large, 1.5 to 2 cm. high, usually solitary, radiate; involucre broadly campanulate, calyculate; bracts of the involucre narrowly lanceolate, 10 to 14 mm. long, pubescent-tipped, otherwise glabrous and purplish; ray-flowers 10 to 18, rays yellow; disk-flowers very numerous; achenes strongly ribbed, glabrous.

Distribution: high mountains of Colorado.

Specimens examined:

Colorado: Gray's Peak, 1 Aug., 1862, *Parry* (Gray Herb., Kew Herb., and Mo. Bot. Gard. Herb.), TYPE; Lat. 39°41′ N., coll. of 1862, *Hall & Harbour 319* (Gray Herb., Kew Herb., U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); South Park, alt. 3960 m., Lieut. Wheeler's Expedition, 1873, *Wolf & Rothrock 573, 575* (Gray Herb. and U. S. Nat. Herb.); Mt. La Plata, alt. 4265 m., Hayden's U. S. Geol. Survey, 1873, *Coulter* (Gray Herb. and Field Mus. Herb.); Sangre de Cristo, Aug., 1873, *Brandegee 724* (U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Sawatche Range, coll. of 1880, *Brandegee* (Mo. Bot. Gard. Herb.); high mountains, Gray's Peak and vicinity, alt. 3350–4265 m., Aug., 1885, *Patterson 84* (Gray Herb., Kew Herb., U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); Gray's Peak, alt.

4265 m., 21 July, 1886, *Letterman 67* (Mo. Bot. Gard. Herb.); Gray's Peak, July, 1888, *Eastwood* (U. S. Nat. Herb.); Mt. Baldy, alt. 3655 m., 11 July, 1891, *Smith* (Mo. Bot. Gard. Herb.); Mt. Princeton, alt. 2115 m., 21 July, 1892, *Sheldon 172, 491* (U. S. Nat. Herb.); stony slopes of Sheep Mountain, alt. 4225 m., coll. of July, 1893, *Purpus 680* (Field Mus. Herb.); La Plata Mountains, alt. 3350–3600 m., 15 July, 1896, *Tweedy 536* (U. S. Nat. Herb.); Cameron Pass, alt. 3600 m., 16 July, 1896, *Baker* (Mo. Bot. Gard. Herb.); Cumberland Mine, La Plata Mountains, alt. 3750 m., 15 July, 1898, *Baker, Earle & Tracy 534* (Gray Herb., Kew Herb., U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); Mt. Baldy, near Breckenridge, alt. 3960 m., Aug., 1901, *Mackenzie 164* (Phil. Acad. Nat. Sci. Herb. and Mo. Bot. Gard. Herb.).

48. S. obovatus Muhl. ex.Willd. Sp. Pl. **3**:1999. 1804; Pursh, Fl. Am. Sept. **2**:530. 1814, and ed. 2, 1816; Nutt. Gen. **2**:165. 1818; Ell. Sketch 329. 1824; Eaton, Manual of Botany 454. 1824; DC. Prodr. **6**:432. 1837; Heller, Cat. N. Am. Pl. 146. 1898, and ed. 2, 230. 1900; Britton & Brown, Ill. Fl. **3**:478, *fig. 4041*. 1898, and ed. 2, 545, *fig. 4627*. 1913; Britton, Manual 1027. 1901, and ed. 2, 1905; Greenm. Rhodora **3**:5. 1901; Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Porter, Fl. Penn. 339. 1903; Keller & Brown, Handb. Fl. Phil. and Vicinity 343. 1905; Small, Fl. Southeastern United States 1304. 1903, and ed. 2, 1913; Greenm. in Gray, Manual, ed. 7, 854. 1908; Graves et al. Conn. Geol. and Nat. Hist. Surv. Bull. No. 14, p. 404. 1910; Small & Carter, Fl. Lancaster County 310. 1913.

S. obtusatus Banks ex Pursh, Fl. Am. Sept. **2**:530. 1814, and ed. 2, 1816; DC. Prodr. **6**:432. 1837.

S. Elliottii Torr. & Gray, Fl. N. Am. **2**:443. 1843; Chapman, Fl. Southern U. S., ed. 1, 245. 1860, and ed. 2, 1889.

S. aureus var. *obovatus* Torr. & Gray, Fl. N. Am. **2**:442. 1843; Gray, Syn. Fl. N. Am. **1**^{2}:391. 1884, and ed. 2, 1886; Macoun, Cat. Canadian Pl. 265. 1884, in part; Chapman, Fl. Southern U. S., ed. 3, 266. 1897.

An herbaceous perennial, glabrous or slightly tomentulose; stems erect, 2 to 5 dm. high, simple or branched, often stoloni-

ferous at the base; stolons slender and elongated to short and rather stout; lower leaves petiolate, obovate, oblong-ovate to subrotund, 1 to 10 cm. long, two-thirds to nearly or quite as broad, rounded at the apex, crenate to doubly serrate, gradually narrowed at the base and decurrent on the petiole or abruptly contracted to a subcordate base; stem-leaves petiolate and sublyrate to sessile, more or less pinnatisect and semiamplexicaul; inflorescence a terminal several to many-headed corymbose cyme; heads 8 to 10 mm. high, radiate; ray-flowers 8 to 12, rays relatively long and narrow, yellow; disk-flowers numerous; achenes glabrous or occasionally hispidulous along the angles.

Distribution: Vermont, south to Georgia, west to Missouri, Kansas, and Texas.

Specimens examined:

Vermont: Pownal, Bennington Co., 31 July, 1898, *Eggleston 264* (Gray Herb.), and 8–11 Sept., 1899, *Eggleston 1381* (U. S. Nat. Herb.).

Massachusetts: Ipswich, coll. of 1842, *Oakes* (Gray Herb. and U. S. Nat. Herb.); Boxford, 22 June, 1878, *E. Faxon* (Gray Herb.); Alford, *Milligan* (U. S. Nat. Herb.); without definite locality, *Nuttall* (Phil. Acad. Nat. Sci. Herb.).

Connecticut: shaded limestone ledges, Salisbury, 3 June, 1901, *Bissell* (Gray Herb.); in loam and on calcareous ledges, Salisbury, 30 May, 1902, *Churchill, Bissell & Fernald 96* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); near Southington, 24 Aug., 1903, *Andrews* (Gray Herb.); Meriden Mountain, 30 May, 1885, *Safford 344* (U. S. Nat. Herb.); rich dry rocky woods, Monroe Co, 8 June, 1895, *Eames* (U. S. Nat. Herb.); thin dry woods on ledge of trap rock, Long Hill, 26 May, 1894, *Eames* (Gray Herb.); Bridgeport, 19 May, 1893, *Eames* (U. S. Nat. Herb.).

New York: Lebanon Springs, 31 May, 1890, *Harrison 9* (U. S. Nat. Herb.); West Point, *ex Herb. Thurber* (Gray Herb.); Van Cortlandt, May, 1893, *Pollard* (U. S. Nat. Herb.); Delaware Co., 6 July, 1892, *H. von Schrenk* (Mo. Bot. Gard. Herb.); without definite locality, *Torr. & Gray, Fl. N. Am.* (Gray Herb.).

New Jersey: dry soil, Cranberry Lake, Sussex Co., 9 June, 1907, *Mackenzie 2616* (U. S. Nat. Herb.); Budd's Lake, Morris Co., 29 May, 1895, *Heritage,* in part, and 30 May, 1895, *Lippincott,* in part (Phil. Acad. Nat. Sci. Herb.); rocky banks, near Charlotteburg, Morris Co., 24 May, 1908, *Mackenzie 3089* (Mo. Bot. Gard. Herb.); above Phillipsburg, Warren Co., 18 May, 1907, *Van Pelt & Long* (Phil. Acad. Nat. Sci. Herb.).

Pennsylvania: Stroudsburg, 2 June, 1900, *ex Herb. Canby* (Phil. Acad. Nat. Sci. Herb.); Bartonsville, 1 July, 1907, *Long & Bartram* (Phil. Acad. Nat. Sci. Herb.); side of Pocono Knob, 31 May, 1902, *Brown* (Phil. Acad Nat. Sci. Herb.); Easton, *Trail Green* (Gray Herb.); Buckskill Falls, 31 May, 1897, *Brown* (Phil. Acad. Nat. Sci. Herb.); Hellertown, 1 June, 1849, *ex Herb. Detwiller* (Phil. Acad. Nat. Sci. Herb.); along Jordan Creek, Lehigh Co., 14 May, 1911, *Pretz 3336* (Phil. Acad. Nat. Sci. Herb.); Nockamixon, 28 May, 1893, *MacElwee,* in part, 19 May, 1906, *Van Pelt & Long,* 26 May, 1902, *Fretz,* and 4 June, 1894, *Crawford* (Phil. Acad. Nat. Sci. Herb.); Nockamixon Rocks, 30 May, 1893, *N. L. Britton* (U. S. Nat. Herb.); Narrowsville, 30 May, 1893, *Brown* (Phil. Acad. Nat. Sci. Herb.); Ivy Rock, below Norristown, 9 May, 1896, *Keller,* and 6 May, 1906, *Van Pelt* (Phil. Acad. Nat. Sci. Herb.); Pennsburg, 20 June, 1910, *Mumbauer 255* (Phil. Acad. Nat. Sci. Herb.); Arcola, *ex Herb. Crawford* (Phil. Acad. Nat. Sci. Herb.); Phoenixville, June, 1865, *ex Herb. Martindale,* and 25 April, 1909, *Bartram* (Phil. Acad. Nat. Sci. Herb.); near Philadelphia, *Griffith 30* (Phil. Acad. Nat. Sci. Herb.); Philadelphia, *ex Herb. Bernhardi* (Mo. Bot. Gard. Herb.); Schuylkill, 5 May, 1834, collector not indicated (Phil. Acad. Nat. Sci. Herb.); Lafayette and Sumneytown, *Williamson* (C. S. Williamson Herb.); in limestone on the Conestoga near Danville Pike Crossing, 17 May, 1901, *Heller* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Conestoga, April, 1889, *Eby* (Mo. Bot. Gard. Herb.); Mountville, Lancaster Co., April, 1889 and 1890, *Eby* (Mo. Bot. Gard. Herb.); McConnellsburg, Fulton Co., 3 June, 1905, *Stone 234* (Phil. Acad. Nat. Sci. Herb.); Johnstown, Cambria Co., *Williams* (C. S.

Williamson Herb.), and 16 June, 1907, *Bartram* (Phil. Acad. Nat. Sci. Herb.); Homewood, 15 June, 1907, *Bartram* (Phil. Acad. Nat. Sci. Herb.); Ohiopyle, Fayette Co., 3–8 July, 1905, *Brown, Crawford & Van Pelt 22, 135* (Phil. Acad. Nat. Sci. Herb.).

Virginia: Great Falls of the Potomac, 21 April, 1908, *Williamson* (Phil. Acad. Nat. Sci. Herb.); on limestone cliffs at edge of river near Schulers, west of Luray, Page Co., 10 May, 1904, *G. S. Miller* (U. S. Nat. Herb.); about Mt. Crawford, Rockingham Co., alt. 365–455 m., 5–13 May, 1893, *Heller* (U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); bluffs of Middle Fork of Holston River, near Marion, Smyth Co., alt. 640 m., 22 May, 1892, *Small* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); vicinity of Marion, 22 May, 1892, *N. L. and E. G. Britton & Vail* (Phil. Acad. Nat. Sci. Herb.).

North Carolina: rocky woods, Hewitt's Station, Swain Co., 24 May, 1897, *Biltmore Herb. 3364a* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Hot Springs and Warm Springs, 24 April, 1887, *Aubrey H. Smith* (Phil. Acad. Nat. Sci. Herb.).

South Carolina: slopes of Paris Mountain, Greenville, 2 April, 1908, *Mackenzie* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.), tomentulose form.

Georgia: bluffs, Rome, coll. of 1882, *ex Herb. Chapman* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.), a form approaching the variety *rotundus*.

Alabama: Boykin, *Buckley* (Gray Herb.); Moulton, Lawrence Co., *Mohr* (U. S. Nat. Herb.); without definite locality, *Wilkinson* (U. S. Nat. Herb.).

West Virginia: White Sulphur Springs, 17–18 May, 1909, *Eggleston 4346* (Mo. Bot. Gard. Herb.); Fairmont, May, 1907, *Williamson* (C. S. Williamson Herb.).

Ohio: near Canton, May, 1875, *ex Herb. Riddell 149* (Mo. Bot. Gard. Herb.); river banks, Lorain Co., 21 April, 1890, *Kofoid* (Mo. Bot. Gard. Herb.); Huron River, Erie Co., *Moseley* (Gray Herb.); Oxford, 2 June, 1908, *Overholts* (Mo. Bot. Gard. Herb.).

Indiana: around lakes, Wells Co., 11 May, 1903, *Deam* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); river bank, north of Notre Dame, 6 June, 1911, *Nieuwland 2660,* and 15 May, 1913, *Nieuwland 11114* (Mo. Bot. Gard. Herb.); Worthington, 29 April, 1889, *Evermann* (U. S. Nat. Herb.).

Kentucky: beargrass hills near Louisville, 20 May, 1853, *Mohr* (U. S. Nat. Herb.); without definite locality, *ex Herb. Short* (Phil. Acad. Nat. Sci. Herb.).

Tennessee: rich bluffs, Knoxville, May, 1896, *Ruth (2)* and in woods, near Knoxville, June, 1896, *Ruth 5* (Mo. Bot. Gard. Herb.); Knoxville, 5 May, 1895, *J. G. Smith* (Mo. Bot. Gard. Herb.); moist woods, Cumberland Mountain, 5 May, 1898, *Eggert* (Mo. Bot. Gard. Herb.); cedar glades, near Lavergne, 4 May, 1898, *Eggert* (Mo. Bot. Gard. Herb.).

Missouri: Jerome, colls. of 1913 and 1914, *J. H. Kellogg 56, 58, 90, 452* (Mo. Bot. Gard. Herb.); Swan, 21 April, 1907, *Bush 4203* (Mo. Bot. Gard. Herb.); Monteer, 12 May, 1901, *Bush 429,* and 14 May, 1905, *Bush 2836* (Mo. Bot. Gard. Herb.); on bluffs, Neck City, Jasper Co., 12 May, 1912, *E. J. Palmer 3669* (Mo. Bot. Gard. Herb.).

Arkansas: Independence, 23 April, 1896, *Eggert* (Mo. Bot. Gard. Herb.); Eureka Springs, 20 April, 1899, *Trelease* (Mo. Bot. Gard. Herb.); Hartford Station, April, 1903, *Pilsbury* (Phil. Acad. Nat. Sci. Herb.); Petit Jean, Yell Co., 1 and 2 April, 1903, *Pilsbury* (Phil. Acad. Nat. Sci. Herb.).

Oklahoma: Vinita, 23 April, 1891, *Carleton 19* (U. S. Nat. Herb.); on creek bank, Page, Leflore Co., 20 April, 1915, *Blakeley 3443* (Mo. Bot. Gard. Herb.).

Texas: river banks, Denison, 28 March, 1890, *Bodin 27* (U. S. Nat. Herb.); near Austin, 17 March, 1908, *York* (Mo. Bot. Gard. Herb.).

Var. **divisifolius** Greenm. var. nov.

Stems bearing short stout stolons; lower leaves obovate to narrowly oblong-oblanceolate, those of the stem relatively long and conspicuously pinnatisect. A local but striking variation from the type.

Distribution: bluffs near Knoxville, Tenn.

Specimens examined:

Tennessee: rich woods, Knoxville, April, 1898, *Ruth 705* (Mo. Bot. Gard. Herb.), TYPE; bluffs, Knoxville, April, 1898, *Ruth 674* (U. S. Nat. Herb.); bluffs, Knoxville, May, 1896, *Ruth (3)* (Mo. Bot. Gard. Herb.); vicinity of Knoxville, 29 April, 1890, *Lamson-Scribner* (U. S. Nat. Herb.).

Var. **elongatus** (Pursh) Britt. in Britton & Brown, Ill. Fl. **3**:478. 1898; Britton, Manual 1027. 1901, and ed. 2, 1905; Porter, Fl. Penn. 339. 1903; Keller & Brown, Handb. Fl. Phil. and Vicinity 343. 1905; Greenm. Monogr. Senecio, I. Teil, 24. 1901, in Engl. Bot. Jahrb. **32**:20. 1902, and in Gray, Manual, ed. 7, 854. 1908.

S. elongatus Pursh, Fl. Am. Sept. **2**:529. 1814, and ed. 2, 1816.

S. aureus var. *discoidea* Porter in herb., not *S. aureus* var. *discoideus* Hook.

Habit and foliage of the species; peduncles of the inflorescence relatively long; heads discoid.

Distribution: eastern Pennsylvania and New Jersey.

Specimens examined:

New Jersey: Budd's Lake, Morris Co., 29 May, 1895, *Heritage,* in part, and 30 May, 1895, *Lippincott,* in part (Phil. Acad. Nat. Sci. Herb.).

Pennsylvania: vicinity of Easton, coll. of 1807, *Pursh, ex Herb. Lambert* (Gray Herb.); College Hill, Easton, June, 1867, *Porter* (Gray Herb.); College Hill, 1 June, 1868, *Porter,* and coll. of 1868, *Garber* (Phil. Acad. Nat. Sci. Herb.); College Hill, June, 1870, *Porter* (U. S. Nat. Herb.); College Hill, May, 1871, *Porter* (Mo. Bot. Gard. Herb.); Spruce Hill on Bushkill Creek, 25 May, 1887, *Porter* (Phil. Acad. Nat. Sci. Herb.); College Hill, 12 May, 1890, *Porter* (Gray Herb. and U. S. Nat. Herb.); Nockamixon, Bucks Co., 28 May, 1893, MacElwee (Phil. Acad. Nat. Sci. Herb.), in part; College Hill, 17 May, 1895, *Porter* (Phil. Acad. Nat. Sci. Herb.); limestone bluffs on the Bushkill, 5 May, 1899, *Porter* (Phil. Acad. Nat. Sci. Herb.); "hillsides, near the Schuylkill and Susquehanna", *ex. Herb. David Townsend* (Phil. Acad. Nat. Sci. Herb.).

Var. **rotundus** Britt. in Britton & Brown, Ill. Fl. **3**:479. 1898. Britton, Manual 1027. 1901, and ed. 2, 1905; Greenm. Monogr. Senecio, I. Teil, 24. 1901, in Engl. Bot. Jahrb. **32**:20. 1902, and in Gray, Manual 854. 1908; Blankenship in Mo. Bot. Gard. Ann. Rept. **18**:179. 1907.

S. rotundus Small, Fl. Southeastern U. S. 1304. 1903, and ed. 2, 1913.

S. Lindheimeri Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

Habit, inflorescence, and technical characters of the head like the species; basal leaves usually long-petioled, the blade obovate to subrotund, cuneate to abruptly constricted into a subcordate base.

Distribution: Ohio to eastern Kansas and south to Louisiana and Texas.

Specimens examined:

Ohio: Oak Point, Lorain Co., 11 May, 1895, *Ricksecker* (U. S. Nat. Herb.); Franklin Co., 7 May, 1892, *Werner 133* (Gray Herb.); central Ohio, *Sullivant* (Gray Herb.); vicinity of Miami, coll. of 1835, *Dr. Frank* (Mo. Bot. Gard. Herb.); Dayton, collector not indicated (Gray Herb.); near Cincinnati, *Lloyd* (Mo. Bot. Gard. Herb.).

Missouri: flood plain of Fox Creek, near Allenton, St. Louis Co., 25 May, 1914, *Drushel* (Mo. Bot. Gard. Herb. and J. A. Drushel Herb.); wet places near Glencoe, 22 May, 1879, *Eggert* (Mo. Bot. Gard. Herb.); Meramec Highlands, 7 May, 1898, *Norton* (Mo. Bot. Gard. Herb.); Pacific, 24 May, 1915, *Drushel* (J. A. Drushel Herb.); Jefferson City, 6 May, 1866, *Krause* (Mo. Bot. Gard. Herb.); Kimmswick, 10 May, 1885, *Wislizenus 226* (Mo. Bot. Gard. Herb.), in part; Monteer, 11 May, 1905, *Bush 2822* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Pleasant Grove, 20 May, 1900, *Bush 340, 710* (Mo. Bot. Gard. Herb. and U. S. Nat. Herb.); near Webb City, 4 May, 1902, *E. J. Palmer 314* (Mo. Bot. Gard. Herb.); Oronogo, 13 and 30 May, 1906, *E. J. Palmer 859* (Mo. Bot. Gard. Herb.); La Russell, 22 May, 1908, *E. J. Palmer 1342* (Mo. Bot. Gard. Herb.); Prosperity, 11 May, 1909, *E. J. Pal-*

mer 1667 (Mo. Bot. Gard. Herb.); Alba, 30 May, 1909, *E. J. Palmer 1834* (Mo. Bot. Gard. Herb.); Carterville, 14 April, 1912, *E. J. Palmer 3521* (Mo. Bot. Gard. Herb.); Eagle Rock, 22 May, 1898, *Bush 262* (Mo. Bot. Gard. Herb.); open ground, McDonald Co., 24 May, 1891, *Bush 871* (Mo. Bot. Gard. Herb.); rich hillside woods, Noel, 4 May, 1914, *E. J. Palmer 5478* (Mo. Bot. Gard. Herb.).

Arkansas: Fulton, 18 April, 1901, *Sargent, Trelease & Bush 143* (Phil. Acad. Nat. Sci. Herb.); Texarkana, 6 April, 1905, *Bush 2241* (Mo. Bot. Gard. Herb.).

Louisiana: without definite locality, *Hale* (Gray Herb.).

Kansas: wet soil, Bourbon Co., 5 May, 1897, *Hitchcock 1118* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.).

Oklahoma: Sapulpa, 29 April, 1895, *Bush 976* (Mo. Bot. Gard. Herb.).

Texas: San Augustine, *Crocket* (U. S. Nat. Herb. 500119); Livingston, Polk Co., 9 April, 1914, *E. J. Palmer 5189* (Mo. Bot. Gard. Herb.); Grand Saline, *Reverchon* (Mo. Bot. Gard. Herb.); Marshall, Harrison Co., 17 April, 1914, *E. J. Palmer 5285* (Mo. Bot. Gard. Herb.); Mill Creek bottom, Washington Co., 26 Feb., 1844, *Lindheimer* (Mo. Bot. Gard. Herb. and Gray Herb.); rich woods, Dallas, 13 March, 1901, *Reverchon 556* (Mo. Bot. Gard. Herb.); Gillespie Co., *Jermy* (Mo. Bot. Gard. Herb.); Comal Spring, New Braunfels, *Lindheimer 446* (Mo. Bot. Gard. Herb.); New Braunfels, colls. of 1850 and 1851, *Lindheimer 510, 958, 959, 960* (U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); New Braunfels, alt. 228 m., 17–19 April, 1903, *Pilsbury* (Phil. Acad. Nat. Sci. Herb.); without definite locality, *Wright* (Gray Herb.).

Var. **umbratilis** Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

Lower leaves petiolate, obovate, oblong-ovate to oblong-elliptic, 2 to 8 cm. long, 1.5 to 5.5 cm. broad, petioles 2 to 12 cm. long.

Distribution: occurring occasionally with the species, especially in shady places from Indiana and Virginia to Louisiana.

Specimens examined:

Indiana: without definite locality, *Clapp* (Gray Herb.), TYPE.

Virginia: shaded rocks, Bedford Co., 9 May, 1871, *A. H. Curtiss* (Gray Herb.).

Kentucky: flat wet barrens, Henderson Co., 5 May, 1842, *Short* (Phil. Acad. Nat. Sci. Herb.).

Tennessee: marsh, Jackson, 15 April, 1893, *Bain 421* (Gray Herb.).

Missouri: Monteer, 27 April, 1907, *Bush 4337* (Mo. Bot. Gard. Herb.).

Arkansas: in woods, Fulton, 15 April, 1902, *Bush 1356* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); on low ground, Fulton, 17 April, 1905, *Bush 2355* (Mo. Bot. Gard. Herb.); Judsonia, 15 May, 1877, *Reynolds* (Field Mus. Herb.); Texarkana, 16 May, 1901, *Trelease* (Mo. Bot. Gard. Herb.); without definite locality, *Dr. Pitcher* (Phil. Acad. Nat. Sci. Herb.).

49. **S. Cardamine** Greene, Bull. Torr. Bot. Club **8**:98. 1881; Gray, Syn. Fl. N. Am. **1**^{2}:390. 1884, and ed. 2, 1886; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Wooton & Standley, Contr. U. S. Nat. Herb. **19**:747. 1915.

A low herbaceous perennial, glabrous throughout or slightly tomentulose in the leaf-axils; roots fibrous; stems one to several from a stoutish rootstock, 1 to 3.5 dm. high; leaves mostly radical, petiolate, round-ovate, 1 to 5 cm. long and broad, deeply cordate, crenate, green above, purple-tinged beneath; petioles 2 to 9 cm. long; stem-leaves 1 to 3, more or less amplexicaul, the uppermost sessile and much reduced; heads few, 1 to 3, about 1 cm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre lanceolate, 6 to 8 mm. long; ray-flowers 8 to 10, rays yellow; disk-flowers numerous, achenes glabrous.

Distribution: mountains of southwestern New Mexico.

Specimens examined:

New Mexico: Mogollon Mountains, 25 April, 1881, *Greene* (Gray Herb., Greene Herb., Kew Herb., Torrey Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.), TYPE; Mogollon Mountains, Willow Creek, 8 Aug., 1900, *Wooton* (U. S. Nat. Herb. 739065).

50. S. cyclophyllus Greenm. Field Col. Mus. Bot. Ser. **2**:276. 1907.

An herbaceous perennial; stem simple, 3.5 to 5 dm. high, sparingly tawny tomentulose at the base and in the axils of the leaves, otherwise glabrous, striate, somewhat purplish; radical and lowermost stem-leaves subrotund, 4 to 7 cm. long, equally broad, deeply cordate, crenate-dentate, green and glabrous above, purple beneath, petioles 5 to 8 cm. long; upper stem-leaves sessile, amplexicaul, pinnately divided into narrowly obovate-cuneate, unequally dentate lateral divisions and a relatively large subreniform terminal division; inflorescence a terminal many-headed subcorymbose cyme; heads 7 to 9 mm. high, radiate; involucre campanulate, sparingly calyculate with minute bracteoles, glabrous; bracts of the involucre about 21, lance-linear, 5 to 6 mm. long, acute, more or less purple-tipped; ray-flowers about 13, rays yellow; disk-flowers 50 to 60; mature achenes 2 mm. long, hispidulous.

Distribution: northeastern Mexico.

Specimens examined:

Nuevo Leon: near Monterey, coll. of 1906, *Pringle 10230* (Gray Herb., photograph in Field Mus. Herb. and Mo. Bot. Gard. Herb.), TYPE; Cerro la Scilla, near Monterey, 20 March, 1902, *Nelson 6672* (Gray Herb.).

51. S. quebradensis Greenm.[1]

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[1]**Senecio quebradensis** Greenm. sp. nov., herbaceus perennis glabrus vel praesertim in axillis foliorum albo-floccosus; caule simplice vel ramoso 1.5–4 dm. alto striato glabro; foliis inferioribus petiolatis rotundo-ovatis vel oblongo-ovatis 1–6 cm. longis, 1–5 cm. latis plerumque cordatis crenato-dentatis utrinque glabris vel juventa parce floccoso-tomentulosis et mox glabratis subinde purpurascentibus; foliis inferioribus plus minusve pinnatisectis et amplexicaulibus; inflorescentiis terminalibus corymboso-cymosis; capitulis paucis vel numerosis 8–10 mm. altis radiatis; involucro campanulato calyculato glabro; bracteis involucri 13–21 lineari-lanceolatis 5–6 mm. longis acutis penicillatis; floseulis liguliferis 8–10, ligulis flavis; floribus disci numerosis; achaeniis valde costatis glabris.—Collected at Quebrada Honda, State of Durango, Mexico, 20 and 21 May, 1906, *Palmer 213* (Gray Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.), TYPE.

An herbaceous perennial, glabrous or white-floccose in the leaf-axils and on the margins of the petioles; stem simple or branched, 1.5 to 4 dm. high from a stout rootstock, striate, glabrous; lower leaves petiolate, round-ovate to ovate-oblong, 1 to 6 cm. long, 1 to 5 cm. broad, usually cordate, crenate-dentate, glabrous on both surfaces or slightly floccose-tomentulose in the early stages but soon glabrate; upper stem-leaves more or less pinnatisect and amplexicaul; inflorescence a subcorymbose cyme terminating the stem and branches, few to many-headed; heads 8 to 10 mm. high, radiate; involucre campanulate, calyculate, glabrous; bracts of the involucre 13 to 21, linear-lanceolate, attenuate, 5 to 6 mm. long; ray-flowers 8 to 10, rays pale yellow; disk-flowers rather numerous; achenes strongly ribbed, glabrous.

Distribution: western Mexico.

Specimens examined:

Durango: Quebrada Honda, 20–21 May, 1906, *Palmer 213* (Gray Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.), TYPE.

52. S. Pammelii Greenm.[1]

An herbaceous perennial, glabrous or slightly white-tomentulose in the axils of the leaves; stems erect, 2 to 4 dm. high, and, as well as the petioles, more or less purplish towards the base; lower leaves long-petiolate, rotund-ovate, 1 to 2.5 cm. long, nearly or quite as broad, shallowly cordate or subtruncate, crenate to nearly entire; upper stem-leaves petiolate and somewhat lyrate to sessile and pinnatisect to entire; inflo-

[1]**Senecio Pammelii** Greenm. sp. nov., herbaceus perennis ubique glabrus vel in axillis foliorum paululo albo-tomentulosus; caulibus erectis 2–4 dm. altis ad basin petiolis etiam plus minusve purpurascentibus; foliis inferioribus longi-petiolatis rotundo-ovatis 1–2.5 cm. longis et latis brevi-cordatis vel subtruncatis crenatis vel fere integris; foliis superioribus petiolatis et sublyratis vel sessilibus et pinnatisectis; inflorescentiis corymboso-cymosis; capitulis 7–10 mm. altis paucis vel pluribus radiatis; involucro campanulato calyculato; bracteis involucri 13–21 lineari-lanceolatis 5–6 mm. longis acutis glabris; flosculis liguliferis 10–12, ligulis flavis; floribus disci numerosis; achaeniis glabris.—Collected in Peterson Cañon, Peterson, Utah, alt. 2895 m., 19 July, 1902, *Pammel & Blackwood 3870* (Mo. Bot. Gard. Herb.), TYPE; on Ruby Mountains, near Blaine post-office, Elko Co., Nevada, alt. 2710 m., 27 Aug., 1913, *Heller 11096* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

This species may be looked for in herbaria under *S. aureus*, also under *S. rubricaulis* having been distributed under both names.

rescence a few to many-headed corymbose cyme; involucre campanulate, sparingly calyculate; heads 7 to 10 mm. high, radiate; bracts of the involucre 13 to 21, linear-lanceolate, 5 to 6 mm. long, acute, glabrous; ray-flowers 10 to 12, rays bright yellow; disk-flowers numerous; achenes glabrous.

Distribution: mountains of Utah and Nevada.

Specimens examined:

Utah: moist rocks and shady woods, Peterson Cañon, Peterson, alt. 2895 m., 19 July, 1902, *Pammel & Blackwood 3870* (Mo. Bot. Gard. Herb.), TYPE.

Nevada: Ruby Mountains, near Blaine post-office, Elko Co., alt. 2710 m., 27 Aug., 1913, *Heller 11096* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

53. S. aureus L. Sp. Pl. **2**:870. 1753, ed. 2, 1220. 1763, and ed. 3, 1220. 1764; Michx. Fl. **2**: 120. 1803; Willd. Sp. Pl. **3**:1998. 1804; Pursh, Fl. Am. Sept. **2**:530. 1814, and ed. 2, 1816; Nutt. Gen. **2**:165. 1818; Ell. Sketch **2**:331. 1824; Bigel. Fl. Bost. 307. 1824; Sprengl, Syst. Veg. **3**:560. 1826, excl. syn.; DC. Prodr. **6**:432. 1837; Torr. & Gray, Fl. N. Am. **2**:442. 1843, in part; Torr. in Nicollet's Report, App. B, 153 [237]. 1843; Gray, Syn. Fl. N. Am. 1^2:391. 1884, and ed. 2, 1886, in part; Macoun, Cat. Canadian Pl. 264. 1884, in part; Millsp. Med. Pl. **1**:91, *pl. 91*. 1892; Goodale, Wild Fls. of Am. 77, *pl. 15*. 1894; Britton & Brown, Ill. Fl. **3**:480, *fig. 4047*. 1898, and ed. 2, 544, *fig. 4625*. 1913, in part; Greenm. in Rhodora **3**:4. 1901; Monogr. Senecio, I. Teil, 23. 1901, and in Engl. Bot. Jahrb. **32**:19. 1902; Britton, Manual 1028. 1901, and ed. 2, 1905; Greenm. in Gray, Manual, ed. 7, 854. 1908; Small & Carter, Fl. Lancaster County 310. 1913.

S. tussilaginoides Walt. Fl. Carol. 208. 1788.

S. rotundifolius Stokes, Bot. Mat. Med. **4**:215. 1812.

S. fastigiatus Schwein. ex Ell. Sketch **2**:331. 1824.

An herbaceous perennial; stems one to several from a relatively slender rootstock, 3 to 6 dm. high, glabrous or not infrequently white-tomentulose in the leaf-axils, along the margins of the petioles, and in the inflorescence; lower leaves petiolate, undivided and rotund-ovate, somewhat triangular-ovate to

oblong-ovate, 1 to 14 cm. long, two-thirds to nearly or quite as broad, crenate to doubly serrate-dentate, usually deeply cordate at the base, green on both surfaces or tinged with purple beneath, glabrous or occasionally slightly tomentulose in the early stages and soon glabrate; petioles 1.5 to 25 cm. long; stem-leaves variable, petiolate to sessile and amplexicaul, lyrate to pinnatisect, reduced towards the inflorescence sometimes to linear entire bracts; inflorescence a terminal several to many-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, calyculate, glabrous or occasionally slightly tomentulose; bracts of the involucre (13–) 21, linear, acute, 6 to 8 mm. long; ray-flowers 8 to 12, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: Labrador to Georgia, and west to North Dakota and Arkansas.

Specimens examined.

Labrador: shore of Seal Lake, 3 Aug., 1896, *Spreadborough 14387* (Geol. Surv. Canada Herb.).

Newfoundland: north of Placentia Junction, 11 Aug., 1894, *Robinson & Schrenk* (Gray Herb. and U. S. Nat. Herb.); banks of Salmonier River, 21 Aug., 1894, *Robinson & Schrenk* (Gray Herb., Geol. Surv. Canada Herb., and U. S. Nat. Herb.); Benoist's Cove, Bay of Islands, July, 1895, *Waghorne* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); between Port-aux-Basques and Bay of Islands, July, 1902, collector not indicated (Gray Herb.).

Prince Edward Island: wet meadows, Tignish, 27 July, 1888, *Macoun 14812* (Geol. Surv. Canada Herb.).

Nova Scotia: Arcadia, Yarmouth Co., 29 June, 1911, *Metheny* (Phil. Acad. Nat. Sci. Herb.).

New Brunswick: swamps, Tobique, July, 1884, *Hay 14817* (Geol. Surv. Canada Herb.); along the St. John River, above Woodstock, 3 July, 1899, *Macoun 22537* (Geol. Surv. Canada Herb.).

Quebec: damp thickets, Lake Mistassini, 24 July, 1885, *Macoun 14819* (Geol. Surv. Canada Herb.); Fort Chimo, on the Ungava River, 31 Aug., 1896, *Spreadborough 14386*

(Geol. Surv. Canada Herb.); in swamps and marshes, Anticosti Island, 20 Aug., 1883, *Macoun 14816* (Geol. Surv. Canada Herb.); swamps and sandy woods, River Ste. Anne des Monts, Gaspé, 19 Aug., 1882, *Macoun 14821* (Geol. Surv. Canada Herb.); banks of Grand River, Gaspé Co., 30 June–3 July, 1904, *Fernald* (Gray Herb.); calcareous alpine meadow, Table-top Mountain, Gaspé Co., alt. 1000–1125 m., 7 Aug., 1906, *Fernald & Collins 260* (U. S. Nat. Herb.); coniferous forest, Low's Trail from the Forks of River Ste. Anne des Monts to Table-top Mountain, Gaspé Co., alt. 550 m., *Fernald & Collins 765*, *766*, and *767* (Gray Herb.); mossy arbor-vitae woods, east of Grande Coupe, Percé, Gaspé Co., 6 Aug., 1907, *Fernald & Collins 1208* (Gray Herb.); alluvial woods, mouth of Bonaventure River, Bonaventure Co., 31 July, 1902, *Williams & Fernald* (Gray Herb.); wet alluvial shores, gravelly beaches and flats, between Baldé and the Baie des Chaleurs, Bonaventure River, 5–8 Aug., 1904, *Collins, Fernald & Pease* (Gray Herb.); alluvial thickets, between the Forks and Brûle Brook, Little Cascapedia River, 29 and 30 July, 1904, *Collins, Fernald & Pease* (Gray Herb.).

Ontario: in a bog, Rainy Lake, Algonquin Park, 12 June, 1900, *Macoun 21869* (Geol. Surv. Canada Herb.); river banks, Inglewood, 4 July, 1890, *White 14823* (Geol. Surv. Canada Herb.); swamps and sandy woods, Kammistiquia River, 13 July, 1869, *Macoun 14814* (Geol. Surv. Canada Herb.); Glen Elgin, Lincoln Co., 10 June, 1897, *McCalla 662, 22779* (Geol. Surv. Canada Herb.); swamps above Leamington, 30 May, 1901, *Macoun 26671* (Geol. Surv. Canada Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); London, June, 1884, *Burgess* (U. S. Nat. Herb.); Amherstburg, 9 June, 1882, *Macoun 14813* (Geol. Surv. Canada Herb.).

Maine: wet thickets, Limestone, Aroostook Co., 20 June, 1898, *Fernald 2403* (Gray Herb.); arbor-vitae swamp, Presque Isle, 12 July, 1902, *Williams, Collins & Fernald* (Gray Herb.); cedar swamp and clearings, Blaine, 23 June, 1898, *Fernald 2404* (Gray Herb.).

New Hampshire: Greenville, 6 June, 1897, *Fernald* (Gray Herb.); sphagnum bog, Jaffrey, 10 July, 1897, *Robinson 590* (Gray Herb.).

Vermont: Peacham, 1 July, 1888, *F. Blanchard* (Mo. Bot. Gard. Herb.); Brandon, 8 June, 1883, *Knoulton* (U. S. Nat. Herb.); Castleton, 3 June, 1898, *Eggleston* (Mo. Bot. Gard. Herb.); Windham, 25 July, 1901, *W. H. Blanchard* (Gray Herb.); Manchester, 27 June, 1898, *Day 102* (Gray Herb. and U. S. Nat. Herb.).

Massachusetts: Hamilton, Essex Co., *Oakes* (Gray Herb.); near Boston, 13 June, 1854, *ex Herb. Wm. Boot* (Gray Herb.); without definite locality, *Pickering* (Phil. Acad. Nat. Sci. Herb.); Boston, *ex Herb. Short* (Phil. Acad. Nat. Sci. Herb.); Arlington Heights, 5 June, 1904, *Greenman 3005* (Mo. Bot. Gard. Herb.); Concord, 30 May, 1896, *Greenman 305* (Mo. Bot. Gard. Herb.); Purgatory Swamp, Dedham, 30 May, 1897, *Greenman 280* (Mo. Bot. Gard. Herb.); Holbrook, 18 June, 1899, *Greenman 609* (Mo. Bot. Gard. Herb.); South Framingham, 18 May, 1890, *Sturtevant* (Mo. Bot. Gard. Herb.); Nonquitt, 21–30 May, 1889, *Sturtevant* (Mo. Bot. Gard. Herb.); Southampton, *ex Herb. Chapman* (Mo. Bot. Gard. Herb.).

Rhode Island: Monns Swamp, Providence, 24 May, 1891, *Collins* (Gray Herb.); Providence, coll. of 1846, *Thurber* (Gray Herb.), 10 June, 1900, *Chamberlain 154* (U. S. Nat. Herb.), and without date, *Olney* (Kew Herb.).

Connecticut: Southington, 30 May, 1896, *Andrews 4* (Gray Herb.), 25 May, 1897, *Bissell 112, 1480* (Mo. Bot. Gard. Herb.); Waterbury, 3 June, 1888, *Du Bois* (U. S. Nat. Herb.); New Haven, without date, *Eaton* (Gray Herb.); near Maltby Park, New Haven, 28 May, 1884, *Safford 85* (U. S. Nat. Herb.); Bridgeport, 25 May, 1896, *Eames* (U. S. Nat. Herb.).

New York: Lebanon Springs, 31 May, 1898, *Harrison 8* (U. S. Nat. Herb.); vicinity of North Harpersfield, Delaware Co., June, 1906, *Topping 69, 103, 106* (U. S. Nat. Herb.); vicinity of Oneida, June–July, 1914, *Maxon* (U. S. Nat. Herb.); near Syracuse, *Straub* (U. S. Nat. Herb.); Ithaca, 3 and 21 June, 1885, *Coville,* 21 June, 1889, *Pearce,* and 31

May, 1890, *Rowlee* (U. S. Nat. Herb.); near Ithaca, coll. of 1889, *Norris* (Mo. Bot. Gard. Herb.); Cascadilla Creek, 6 June, 1877, *Trelease* (Mo. Bot. Gard. Herb.); Fall Creek, 14 June, 1893, *Schrenk* (Mo. Bot. Gard. Herb.); western New York, collector and date not indicated (Gray Herb.); Clove Lake, Staten Island, 28 May, 1905, *Dowell 3764* (Mo. Bot. Gard. Herb.).

New Jersey: New Durham, *Brownne* (Kew Herb.); Tenafly, 26 May, 1894, *Pollard* (U. S. Nat. Herb.); Fairview, 23 May, 1895, *Van Sickle* (U. S. Nat. Herb.); Charlotteburg, 24 May, 1908, *Mackenzie 3085* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Newfoundland, 14 June, 1908, *Mackenzie 3127* (U. S. Nat. Herb.); Mt. Tabor, 16 June, 1907, *Mackenzie 2640* (Mo. Bot. Gard. Herb.); Budd's Lake, 28 May, 1895, *Heritage* (Phil. Acad. Nat. Sci. Herb.); Bound Brook, 31 May, 1904, *House* (U. S. Nat. Herb.); river bank above Crosswick's Creek, 29 May, 1904, *Williamson* (C. S. Williamson Herb.); Batsto, 22 May, 1912, *Bassett 17* (Phil. Acad. Nat. Sci. Herb.); shore of Delaware River, Camden Co., 10 May, 1910, *Long 3259* (Phil. Acad. Nat. Sci. Herb.); Washington Park, 9 May, 1897, *Jahn* (Phil. Acad. Nat. Sci. Herb.); below Washington Park, 15 May, 1895, *Jahn* (Phil. Acad. Nat. Sci. Herb.); Glassboro, 14 May, 1910, *Long 3346* (Phil. Acad. Nat. Sci. Herb.); Bennett, 29 Oct., 1912, *Long 7954* (Phil. Acad. Nat. Sci. Herb.); without locality or date, *Read* (Phil. Acad. Nat. Sci. Herb.).

Pennsylvania: Milford, May, 1905, *Mell* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Tobyhanna Mills, 3 July, 1893, *Crawford* (Phil. Acad. Nat. Sci. Herb.); in deep shaded bog, Tobyhanna, 27 July, 1907, *Bartram* (Phil. Acad. Nat. Sci. Herb.); bog near Easton, 18 May, 1894, *Tyler* (Phil. Acad. Nat. Sci. Herb.); Hellertown, *ex Herb. Detwillert* (Phil. Acad. Nat. Sci. Herb.); streamlet east of Slatington reservoir, 2 June, 1912, *Pretz 4512* (Phil. Acad. Nat. Sci. Herb.); Threemile Run, 21 May, 1886, *Fretz* (Phil. Acad. Nat. Sci. Herb.); Rock Hill, 2 June, 1889, *Pollard* (U. S. Nat. Herb.); Sellersville, June, 1887, *Fretz* (Phil. Acad. Nat. Sci. Herb.); Doyles-

town, 18 May, 1883, *Pond* (U. S. Nat. Herb.); Woodbourne, 30 May, 1904, *Brown* (Phil. Acad. Nat. Sci. Herb.); Tullytown, 30 May, 1899, *Williamson* (C. S. Williamson Herb.); Tullytown, 3 May, 1899, *Crawford* (Phil. Acad. Nat. Sci. Herb.); Tullytown, 20 May, 1899, *Fretz* (Phil. Acad. Nat. Sci. Herb.); Bucks Co., coll. of 1867, *Allen* (Phil. Acad. Nat. Sci. Herb.); Shannonville, 12 June, 1891, *Crawford* (Phil. Acad. Nat. Sci. Herb.); Arcola, 6 May, 1892, *Crawford* (Phil. Acad. Nat. Sci. Herb.); Merion, 25 April, 1871, *Redfield* (Mo. Bot. Gard. Herb.); French Creek Falls, *MacElwee* (Phil. Acad. Nat. Sci. Herb.); Darby Creek, near Paoli, 21 May, 1905, *Bartram* (Phil. Acad. Nat. Sci. Herb.); Westtown Meadow, 7 May, 1890, *N. H. C.* (Phil. Acad. Nat. Sci. Herb.); near Pocopson, 27 May, 1904, *Painter 628* (Mo. Bot. Gard. Herb.); near Brandywine, *Townsend* (Phil. Acad. Nat. Sci. Herb.); New Garden, 29 May, 1904, *Vanatta* (Phil. Acad. Nat. Sci. Herb.); Haverford, *D. B. Smith* (Kew Herb.); west side of Wissahickon River, 18 June, 1834, collector not indicated (Phil. Acad. Nat. Sci. Herb.); West Philadelphia, 4 May, 1890, *MacElwee 475* (Phil. Acad. Nat. Sci. Herb.); Crum Creek, near Philadelphia, 6 June, 1867, *Redfield* (Mo. Bot. Gard. Herb.); Crum Creek, 30 May, 1898, *Githens* (Phil. Acad. Nat. Sci. Herb.); Byberry, coll. of 1862, *Martindale* (Phil. Acad. Nat. Sci. Herb.); near Mickelton, 14 May, 1892, *Heritage* (Phil. Acad. Nat. Sci. Herb.); Delaware Co., 10 May, 1891, *MacElwee* (Phil. Acad. Nat. Sci. Herb.); Clifton, 7 May, 1893, *Lloyd* (Phil. Acad. Nat. Sci. Herb.); Dillerville swamp, Lancaster Co., 30 May, 1901, *Heller* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); on Little Conestoga near Stoneroad's Mill, 23 May, 1901, *Heller* (Gray Herb. and U. S. Nat. Herb.); between York Furnace and Tucquam, 11 May, 1901, *Heller* (Gray Herb. and U. S. Nat. Herb.); Fishing Creek, 16 May, 1906, *Carter* (Phil. Acad. Nat. Sci. Herb.); west branch of Octoraro Creek, 6 May, 1891, *Small & Heller* (U. S. Nat. Herb.); York Furnace, York Co., 13 May, 1899, *MacElwee 201* (Phil. Acad. Nat. Sci. Herb.); Meadow-ground Mountain, Fulton Co., 4 June, 1905, *Stone 226* (Phil. Acad.

Nat. Sci. Herb.); Mt. Alto, coll. of 1900, *Illick* (Mo. Bot. Gard. Herb.).

Delaware: Granogue, 27 May, 1896, *Commons* (Phil. Acad. Nat. Sci. Herb.); near Centerville, 26 May, 1875, *Commons* (Phil. Acad. Nat. Sci. Herb.); Green Bank, 12 May, 1884, *Commons* (Phil. Acad. Nat. Sci. Herb.); Elsmere, 14 May, 1894, *Commons* (Phil. Acad. Nat. Sci. Herb.); west branch of Naaman's Creek, 15 May, 1909, *Pennell 2040* (Phil. Acad. Nat. Sci. Herb.).

Maryland: along the Susquehanna River, Cecil Co., 18 April, 1913, *St. John & Long 8076* (Phil. Acad. Nat. Sci. Herb.); Calreston, 5 May, 1889, *Thurston* (U. S. Nat. Herb.); near Great Falls, Montgomery Co., 18 May, 1900, *M. F. Miller* (U. S. Nat. Herb.); Plummer's Island, near Cabin John, 30 April, 1902, *Kearney & Maxon* (U. S. Nat. Herb.); Montgomery Co., near Washington, *Batchelder* (Phil. Acad. Nat. Sci. Herb.); Marlboro, 6 May, 1900, *Morris 914* (U. S. Nat. Herb.); Savage River, Garrett Co., 25 April, 1897, *Knowlton* (U. S. Nat. Herb.).

District of Columbia: Washington, coll. of 1873, *Vasey* (U. S. Nat. Herb.); High Island, 2 April, 1876, *Ward* (U. S. Nat. Herb.); vicinity of Washington, 10 June, 1877, *Ward* (U. S. Nat. Herb.); without definite locality, 29 April, 1888, *Burgess* (U. S. Nat. Herb.); National Park, 6 May, 1892, *F. Blanchard* (Mo. Bot. Gard. Herb.); Glen Echo, 24 April, 1895, *Pollard 89* (U. S. Nat. Herb.); Rock Creek Park, 4 May, 1896, *Steele* (Gray Herb. and U. S. Nat. Herb.); High Island, April, 1898, *Williamson* (C. S. Williamson Herb.); pine woods, Dalecartia Reservoir, 23 May, 1905, *Painter 1305* (Mo. Bot. Gard. Herb.); Chevy Chase, 16 May, 1905, *House 728* (Mo. Bot. Gard. Herb.).

Virginia: Arlington, April, 1891, *F. Blanchard* (Mo. Bot. Gard. Herb.); Stony Man Mountain, 3 July, 1903, *G. S. Miller* (U. S. Nat. Herb.); on Bear Creek, east of Hungry Hollow, Smyth Co., alt. 830 m., 7 June, 1892, *Small* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); about Chatham Hill Gap, Walker Mountain, alt. 915 m., *Small* (Gray Herb.); Walker Mountain,

alt. 640 m., *E. G. Britton & A. M. Vail* (Phil. Acad. Nat. Sci. Herb.).

North Carolina: Cloudland, Roan Mountain, 25 June, 1902, *Cannon 10* (U. S. Nat. Herb.); vicinity of Asheville, May, 1888, *McCarthy* (U. S. Nat. Herb.); Biltmore, 24 April, 1896, and 13 April, 1897, *Biltmore Herb. 889, 889a* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); mountains of North Carolina, *Ashe* (U. S. Nat. Herb.).

Georgia: without locality, *ex Herb. Chapman 2340* (Mo. Bot. Gard. Herb.).

West Virginia: Upshur Co., 4 May, 1895, and 27 May, 1897, *Pollock* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Ohio: Berea, May, 1895, *Ashcroft* (Mo. Bot. Gard. Herb.); Canton, May, 1835, *Riehl* (Mo. Bot. Gard. Herb.); Columbus, *Sullivant* (Kew Herb.); Champaign Co., 27 May, 1893, *Werner 138* (Gray Herb.).

Michigan: Port Huron, 18 May, 1896, *Dodge 296* (U. S. Nat. Herb.); moist rich woods and river banks, Rochester, May, 1914, *Farwell 3384, 3628½*, and at Parkdale Farms, colls. of May and June, 1912, 1913, *Farwell 2552, 3408, 3425* (Mo. Bot. Gard. Herb.); Owosso, 21 May, 1889, *Hicks* (U. S. Nat. Herb.).

Indiana: Chain Lakes, 6 May, 1913, *Nieuwland 11005* (Mo. Bot. Gard. Herb.); Mineral Springs, 20 May, 1912, *Nieuwland 10019* (Mo. Bot. Gard. Herb.); bank of Wabash River, west of Shively Bridge, 19 May, 1901, *Mackenzie* (U. S. Nat. Herb.); West Lafayette, 10 May, 1912, *Overholts* (Mo. Bot. Gard. Herb.); Jefferson Co., *Hubbard* (Gray Herb.); banks of Lick Creek near Abby Dell, 25 May, 1901, *Mackenzie* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Kentucky: Blue-licks and Mud-lick, *Short* (Phil. Acad. Nat. Sci. Herb.); Bowling Green, May, 1892, *Price* (Mo. Bot. Gard. Herb.).

Illinois: in moist rich thickets and wet meadows near Beach, 16 June, 1907, *Greenman 2007, 2022, 2023* (Mo. Bot. Gard. Herb.); near Woodlawn, Jefferson Co., 16 May, 1898, *Eggert* (Mo. Bot. Gard. Herb.).

Minnesota: Bear Creek, May, 1890, *Holzinger* (U. S. Nat. Herb.).

South Dakota: Brookings, coll. of 1892, *Williams* (U. S. Nat. Herb.); along creeks, Brookings, 26 May, 1894, *Thornber* (Mo. Bot. Gard. Herb.); low ground, Oakwood, 23 May, 1902, *A. G. J.* (Mo. Bot. Gard. Herb.); Custer Co., alt. 1675 m., 16 July, 1892, *Rydberg 827* (Gray Herb.), in part.

Nebraska: Emerson, 12 June, 1893, *Clements 2513* (U. S. Nat. Herb.).

Iowa: Iowa City, *Hitchcock* (Mo. Bot. Gard. Herb.); prairies, near Council Bluffs, Nicollet's North-Western Expedition, 16 May, 1839, *Geyer 97* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.).

Missouri: low ground, Adair Co., 5 May, 1884, *Sheldon* (Mo. Bot. Gard. Herb.); Courtney, coll. of 1880, *Bush* (U. S. Nat. Herb.); banks of River des Peres, near St. Louis, May, 1883, *Engelmann* (Mo. Bot. Gard. Herb.); "Valley Forge", 11 May, 1888, *Pammel* (Mo. Bot. Gard. Herb.); Glencoe, 22 May, 1879, *Eggert* (Mo. Bot. Gard. Herb.); Allenton, April, 1890, *Letterman* (Mo. Bot. Gard. Herb.); Allenton, 23 May, 1892, *Glatfelter 293* (Mo. Bot. Gard. Herb.); Cliff Cave, 26 Aug., 1898, *Norton* (Mo. Bot. Gard. Herb.); Pacific, 4 July, 1879, *Eggert* (Mo. Bot. Gard. Herb.); Pacific, 15 May, 1900, *Norton* (Mo. Bot. Gard. Herb.); Victoria, 10 May, 1890, *Hitchcock* (Mo. Bot. Gard. Herb.); near Sunnyside, 22 May, 1879, *Eggert* (Mo. Bot. Gard. Herb.); De Soto, 22 May, 1892, *Eggert* (Mo. Bot. Gard. Herb.); Valles Mines, May, 1835, *(?)Engelmann* (Mo. Bot. Gard. Herb.); Shannon Co., coll. of 1890, *Bush* (U. S. Nat. Herb.); Monteer, 24 May, 1900, *Bush 370* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); along streams, Monteer, 14 May, 1901, and 29 April, 1907, *Bush 465, 4395* (Mo. Bot. Gard. Herb.); Greene Co., 30 May, 1879, *Shepard* (Gray Herb.); Swan, Taney Co., 21 April, 1907, *Bush 4225* (Mo. Bot. Gard. Herb.); Galena, Stone Co., 3 May, 1914, *E. J. Palmer 5743* (Mo. Bot. Gard. Herb.); Reding's Mill, 9 April, 1909, *E. J. Palmer 1655* (Mo. Bot. Gard. Herb.).

Arkansas: Eureka Springs, Carroll Co., 15 May, 1914, *E. J. Palmer 5623* (Mo. Bot. Gard. Herb.); northwestern Arkansas, April, 1880, *Harvey 45* (Gray Herb.).

Var. **gracilis** (Pursh) Britt. in Britton & Brown, Ill. Fl. **3**:481. 1898; Britton, Manual 1028. 1901, and ed. 2, 1905; Greenm. Monogr. Senecio, I. Teil, 23. 1901, in Engl. Bot. Jahrb. **32**:19. 1902, and in Gray, Manual, ed. 7, 854. 1908; Porter, Fl. Penn. 339. 1903.

S. gracilis Pursh, Fl. Am. Sept. **2**:529. 1814, and ed. 2, 1816; DC. Prodr. **6**:432. 1837; Small, Fl. Southeastern U. S. 1303. 1903, and ed. 2, 1913.

Stems slender; basal leaves relatively small, those of the offshoots, as well as the lower stem-leaves, rotund-ovate to oblong-ovate, 1 to 2 cm. long and nearly to quite as broad. In all other essential characters like the species into which it directly passes.

Distribution: occurring with the species, but especially in moist open places.

Specimens examined:

Ontario: Squirrel Island, 10 June, 1904, *Dodge 14, 297*[a] (U. S. Nat. Herb.).

New Jersey: Point Pleasant, *Williamson* (C. S. Williamson Herb.); meadows, etc., New Egypt, 14 May, 1906, *Grove 315* (Phil. Acad. Nat. Sci. Herb.); Spray, *de Chalmot* (U. S. Nat. Herb.); Swedesboro, 15 May, 1892, *Lippincott* (Phil. Acad. Nat. Sci. Herb.).

Pennsylvania: Wayne, 2 May, 1908, *Bartram* (Phil. Acad. Nat. Sci. Herb.); Lehigh Co., *Pretz 345, 4398, 3272, 6483, 6457* (Phil. Acad. Nat. Sci. Herb.); Bucks Co., coll. of 1860, *Krout* (Phil. Acad. Nat. Sci. Herb.); Nockamixon, coll. of 1893, *Crawford* (Phil. Acad. Nat. Sci. Herb.); near Quakertown, 9 May, 1899, *Fretz* (Phil. Acad. Nat. Sci. Herb.); Rock Hill, 31 May, 1903, *MacElwee* (Phil. Acad. Nat. Sci. Herb.); Tohickon Creek near Doylestown, 30 May, 1902, *Brown* (Phil. Acad. Nat. Sci. Herb.); meadows along Wissahickon Creek, Fort Washington, 7 May, 1909, *Long* (Phil. Acad. Nat. Sci. Herb.); near Ardmore, 15 May, 1909, *Eckfeldt* (Phil. Acad. Nat. Sci. Herb.); near Tredyffrin, 6 May, 1906, *Bartram* (Phil. Acad. Nat. Sci. Herb.); Chester Heights, 9 May, 1909, *Pennell 2030* (Phil. Acad. Nat. Sci. Herb.); Dillerville Swamp,

Lancaster Co., 25 May, 1889, *Heller* (Gray Herb.); New Providence, 18 May, 1900, *Heller* (Mo. Bot. Gard. Herb.); about Penryn, Lebanon Co., 27 May, 1893, *Heller & Halbeck 876* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.).

Delaware: west branch of Naaman's Creek, 15 May, 1909, *Pennell 2044* (Phil. Acad. Nat. Sci. Herb.); near Cooch's Mill, 29 May, 1896, *Commons* (Phil. Acad. Nat. Sci. Herb.).

Maryland: near Great Falls, 8 May, 1895, *Mearns* (U. S. Nat. Herb.).

District of Columbia: Carberry Meadows, 7 May, 1903, *Steele* (Mo. Bot. Gard. Herb.).

Michigan: marl beds on Parkdale Farm, 25 May, 1913, *Farwell 3415* (Mo. Bot. Gard. Herb.); in wet meadows, Grand Rapids, 17 May, 1894, and 26 June, 1897, *Cole* (Gray Herb.).

Illinois: Palos Park, 22 May, 1913, *Millspaugh 3744* (Field Mus. Herb.).

Minnesota: Fort Snelling, coll. of 1888, *Forwood,* also 1 and 14 June, 1891, *Mearns* (U. S. Nat. Herb.); Nicollet, June, 1892, *Ballard* (U. S. Nat. Herb.).

North Dakota: in bogs, Butte, 3 June, 1906, *Lunell* (U. S. Nat. Herb.).

Var. **semicordatus** (Mack. & Bush) Greenm. comb. nov.

S. semicordatus Mack. & Bush, Mo. Bot. Gard. Ann. Rept. **16**:107. 1905.

S. aureus Mack. & Bush, Manual Fl. Jackson County, Mo. 207. 1902, in part, not L.

S. aureus> × *Balsamitae* Greenm. Rhodora **10**:69. 1908.

Lower leaves rotund-ovate to oblong-ovate, 1 to 8 cm. long, 1 to 4 cm. broad, usually rounded at the apex, shallowly cordate.

Distribution: beaches, shores, and prairies. Eastern Quebec, Illinois, and Missouri.

Specimens examined:

Quebec: wet alluvial shores, gravelly beaches and flats, between Baldé and the Baie des Chaleurs, Bonaventure River, 5, 6, and 8 Aug., 1904, *Collins, Fernald & Pease* (Gray Herb., photograph in Field Mus. Herb. and Mo. Bot. Gard. Herb.).

Illinois: in wet meadows near Beach, Lake Co., 16 June, 1907, *Greenman 2022* (Field Mus. Herb., photograph in Mo. Bot. Gard Herb.), in part; low ground, Evanston, *Earl,* also *Price* (U. S. Nat. Herb.).

Missouri: on prairies, Levasy, Jackson Co., 18 May, 1902, *Bush 1678* (Gray Herb. and Mo. Bot. Gard. Herb.), TYPE; swales on prairies, Levasy, 11 May, 1904, *Bush 1940* (Mo. Bot. Gard. Herb.).

Although some of the specimens cited show indications of a possible origin by hybridization, as was indicated in 'Rhodora' in 1908, yet the examination of additional material points rather towards an origin by variation.

54. S. Robbinsii Oakes ex Rusby, in Bull. Torr. Bot. Club **20**:19, *pl. 139*. 1893; Heller, Cat. N. Am. Pl. 147. 1898, and ed. 2, 230. 1900; Britton & Brown, Ill. Fl. **3**:480, *fig. 4046*. 1898, and ed. 2, 544, *fig. 4624*. 1913; Greenm. in Rhodora **3**:4. 1901; Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Small, Fl. Southeastern U. S. 1303. 1903, and ed. 2, 1913; Kennedy in Rhodora **6**:133. 1904; Britton, Manual 1028. 1901, and ed. 2, 1905; Greenm. in Gray, Manual, ed. 7, 854. 1908.

S. aureus var. *lanceolatus* Oakes ex Torr. & Gray, Fl. N. Am. **2**:442. 1843; Macoun, Cat. Canadian Pl. 265. 1884.

S. aureus var. *Balsamitae* Gray, Syn. Fl. N. Am. **1**^{2}:391. 1884, and ed. 2, 1886, in part, as to *S. aureus* var. *lanceolatus* Oakes in synonymy.

An herbaceous perennial, glabrous or slightly tomentose along the margins of the petioles of the leaves, especially near their sheathing base; lower leaves long-petiolate, ovate-rotund to oblong-lanceolate, 1 to 10 cm. long, 1 to 3 cm. broad, crenate to sharply and more or less serrate-dentate, cordate to abruptly narrowed at the base, green and glabrous on both surfaces; upper stem-leaves petiolate and sublyrate or sessile and more or less pinnatisect; inflorescence a terminal several to many-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, calyculate; bracts of the involucre about 21, linear, acute, glabrous; ray-flowers 10 to 12, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: Nova Scotia and Quebec, south to northern New England and New York; also on Roan Mt., North Carolina.

Specimens examined:

Nova Scotia: Margaree, Big Intervale, Cape Breton Island, 19 July, 1898, *Macoun 19717* (Geol. Surv. Canada Herb.); Baddeck, Cape Breton Island, 10 July, 1898, *Macoun 19718* (Geol. Surv. Canada Herb.); Boylston, July, 1890, *Hamilton 22333* (Geol. Surv. Canada Herb.); in swamps and ditches, Truemanville, 30 July, 1883, *Trueman 14773* (Geol. Surv. Canada Herb.); railroad ditch, Truro, 27 July, 1911, *Bartram* (Phil. Acad. Nat. Sci. Herb.).

Prince Edward Island: rocky places, Winslow Road, 16 July, 1888, *Macoun 14794* (Geol. Surv. Canada Herb.).

Quebec: swamp near Georgeville, Lake Memphremagog, 12 July, 1902, *Churchill* (Gray Herb.).

Maine: dry thicket, Van Buren, 24 July, 1893, *Fernald* (Gray Herb.); open swampy woods, Aroostook Co., *Mackenzie 3633* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); damp thickets, Cutler, 5 June, 1902, *Kennedy, Williams, Collins & Fernald* (Gray Herb.); wet meadow, Fitzgerald Pond, near Moosehead Lake, 6 July, 1895, *Fernald 272* (Gray Herb., U. S. Nat. Herb., Greene Herb., and Mo. Bot. Gard. Herb.); meadow near High Head, Mt. Desert, 1 July, 1891, *Redfield* (Phil. Acad. Nat. Sci. Herb. and Mo. Bot. Gard. Herb.); Winthrop, coll. of 1862, *Sturtevant* (Mo. Bot. Gard. Herb.); Hartford, June, 1885, and July, 1892, *Parlin* (Gray Herb.); Westbrook, July, 1900, *Ricker 672* (U. S. Nat. Herb.).

New Hampshire: new gate of Notch, White Mountains, 7 July, 1878, *E. & C. E. Faxon* (Gray Herb.); Crawford Notch, 1 July, 1898, *Greenman 1105* (Gray Herb. and Mo. Bot. Gard. Herb.); wet meadow, Glen House, 10 July, 1910, *Williamson 1421* (C. S. Williamson Herb.); Jackson, 26 July, 1890, *Churchill* (U. S. Nat. Herb.); Jackson, 10 Sept., 1896, *Purdie* (Gray Herb.); Llandoff Valley Meadows, Franconia, 18 June, 1895, *E. & C. E. Faxon* (Gray Herb. and U. S. Nat. Herb.); cedar swamp, Franconia, 19 June, 1895, *E. & C. E. Faxon* (Gray Herb.).

Vermont: cedar swamp, Willoughby Lake, 26 July, 1885, *Deane* (Gray Herb.); Willoughby Mountain, 15 July, 1906, *Williamson* (C. S. Williamson Herb.); Stowe, July, 1899, *Churchill & Greenman 294* (Mo. Bot. Gard. Herb.); Peacham, July, 1892, *F. Blanchard* (Mo. Bot. Gard. Herb.); Starksboro, 10 June, 1898, *Eggleston* (Mo. Bot. Gard. Herb.); Middlebury, 23 and 25 June, 1883, *Brainerd* (Gray Herb); Pittsford, 14 June, 1902, *Eggleston 2783* (Phil. Acad. Nat. Sci. Herb.); on cold bog, Rutland, 21 June, 1899, *Eggleston 1383* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Mendon, 2 July, 1900, *Eggleston 2040* (Mo. Bot. Gard. Herb.); Windham, coll. of 1901, *W. H. Blanchard* (Gray Herb.).

New York: Stony Creek Ponds, Adirondack Mountains, 29 June, 1899, *Rowlee, Wiegand & Hastings* (Gray Herb.); north woods, Herkimer Co., coll. of 1864, *Paine* (Gray Herb.); meadow, South Branch, Herkimer Co., Aug., 1879, *Tweedy* (U. S. Nat. Herb.), form with somewhat less elongated leaves.

North Carolina: summit of Roan Mountain, Mitchell Co., alt. 1920 m., *Small & Heller 234* (Mo. Bot. Gard. Herb.).

55. S. pseudaureus Rydb. Bull. Torr. Bot. Club **24**:298. 1897; *ibid.* **27**: 180, *pl. 5, fig. 10.* 1900; Mem. N. Y. Bot. Gard. **1**:446. 1900; Fl. Colo. 397. 1906; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Piper, Contr. U. S. Nat. Herb. **11**:598. 1906; Nels. in Coulter & Nelson, Manual Cent. Rocky Mountains 582. 1909, in part; Daniels, Univ. Mo. Studies, Sci. Ser. **2**:252. 1911; Wooton & Standley, Contr. U. S. Nat. Herb. **19**:747. 1915.

An herbaceous perennial; stems erect, 3 to 7 dm. high, white-tomentulose in the axils of the leaves, along the margins of the petioles towards their base, and in the inflorescence, otherwise glabrous or nearly so; lower leaves long-petiolate, ovate-rotund to oblong-ovate, 1 to 10 cm. long, 1 to 6 cm. broad, rounded to acute at the apex, shallowly cordate, crenate to doubly serrate with somewhat incurved teeth; petioles 1 to 23 cm. long; stem-leaves petiolate or sessile, undivided or sublyrate to pinnatisect, and usually with rather sharply and doubly serrate-dentate and frequently revolute margins, more

or less attenuate; inflorescence a terminal few to many-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, calyculate; bracts of the involucre (13–) 21, linear, acute, 6 to 8 mm. long, glabrous except at the penicillate tip; ray-flowers 10 to 13, rays pale yellow; disk-flowers numerous; achenes glabrous.

Distribution: Saskatchewan, Alberta and British Columbia, south to New Mexico and California.

Specimens examined:

Saskatchewan: District of Assiniboia, 1 Aug., 1901, *Williamson* (C. S. Williamson Herb.).

Alberta: Laggan, Rocky Mountain Park, 13 July, 1904, *Macoun 65016* (Gray Herb. and Geol. Surv. Canada Herb.); trail to Burgess Pass, Yoho Valley, 28 Aug., 1904, *Macoun 65017* (Gray Herb. and Geol. Surv. Canada Herb.); Lake Louise, alt. 1830–2135 m., 17 July, 1906, *Brown 559* (Phil. Acad. Nat. Sci. Herb.); near Banff, 6 July, 1891, *Macoun* (U. S. Nat. Herb. 232000); Banff, alt. 1340 m., 7 July, 1907, *Butters & Holway 66* (U. S. Nat. Herb.); in swampy places, summit of South Kootenai Pass, 9 Aug., 1881, *Dawson 14768* (Geol. Surv. Canada Herb.); in wet places, North Kootenai Pass, 28 July, 1883, *Dawson 14815* (Geol. Surv. Canada Herb.).

British Columbia: Burgess Trail, vicinity of Field, alt. 1545–1830 m., 29 June and 16 July, 1906, *Brown 518* (Phil. Acad. Nat. Sci. Herb.); in woods, Emerald Lake, alt. 1310 m., 4 Aug., 1904, *Petersen 148* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Bonaparte River, 18 June, 1889, *Macoun* (U. S. Nat. Herb. 219791), in part; Mount St. Thomas, between Kettle and Columbia Rivers, 8 Aug., 1902, *Macoun 64994* (Gray Herb. and Geol. Surv. Canada Herb.); grassy thickets, Guichon Creek, 8 July, 1888, *Dawson 14769* (Geol. Surv. Canada Herb.); damp places, between North Thompson and Bonaparte Rivers, alt. 1220 m., 18 June, 1889, *Macoun 14770* (Geol. Surv. Canada Herb.), in part; Trail, 9 June, 1902, *Macoun 64993* (Geol. Surv. Canada Herb.).

Montana: Midvale, 1 July, 1903, *Umbach 238* (U. S. Nat. Herb.); Big Fork, Flathead Co., 14 June, 1904, *Jones* (U. S. Nat. Herb.); Big Fork, 15 July, 1908, and Swan Lake, 25 Aug., 1908, *Clemens* (Field Mus. Herb. 376698 and 384938); MacDougal Peak, 31 July, 1908, *Clemens* (Mo. Bot. Gard. Herb.); Little Belt Pass, 10 Aug., 1896, *Flodman 918* (Mo. Bot. Gard. Herb.), CO-TYPE; Spanish Basin, Gallatin Co., alt. 1980 m., 28 June, 1897, *Rydberg & Bessey 5263* (Gray Herb., Berlin Herb., and N. Y. Bot. Gard. Herb.); Gallatin Basin, alt. 2130 m., 5 Aug., 1905, *Blankenship 291* (U. S. Nat. Herb., Mo. Bot. Gard. Herb., and Phil. Acad. Nat. Sci. Herb.).

Yellowstone National Park: Lone Star Geyser Basin, 7 Aug., 1897, *Rydberg & Bessey 5262* (U. S. Nat. Herb. and N. Y. Bot. Gard. Herb.); Gibbon Cañon, 28 Aug., 1899, *A. & E. Nelson 6748* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Yellowstone Falls, 5 Aug., 1885, *Letterman 77* (Mo. Bot. Gard. Herb.); without definite locality, 5 Aug., 1902, *Mearns 2860, 2978* (U. S. Nat. Herb.); Amethyst Creek, 14 Aug., 1887, *Knowlton* (U. S. Nat. Herb. 201412).

Colorado: open wet meadow, below Estes Park, 5 July, 1912, *Churchill* (J. R. Churchill Herb.); Wagon Wheel Gap, Mineral Co., July, 1882, *B. H. Smith* (Phil. Acad. Nat. Sci. Herb.); Mancos, 21 June, 1898, *Baker, Earle & Tracy 45* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.).

New Mexico: vicinity of Chama, Rio Arriba Co., alt. 715–870 m., 9 July, 1911, *Standley 6635* (U. S. Nat. Herb.); along the Pecos River, east of Glorieta, San Miguel Co., alt. 1980 m., *A. & E. Heller 3682* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Idaho: West Fork of Priest River, alt. 900 m., 4 Aug., 1897, *Leiberg 2825* (U. S. Nat. Herb.); near Santianne Divide, west side, alt. 850 m., 23 June, 1895, *Leiberg 1020* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Granite Station, Kootenai Co., 30 July, 1892, *Sandberg, MacDougal & Heller 803* (U. S. Nat. Herb.); near Lewiston, 17 June, 1894, *Henderson* (U. S. Nat. Herb.); Fork of Wood River, alt. 1830 m., 25 July, 1895, *Henderson 3235* (U. S. Nat. Herb.); Twilight Gulch, Owyhee Co.,

alt. 1675 m., 23 June, 1911, *Macbride 973* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); House Creek, Owyhee Co., 29 June, 1912, *Nelson & Macbride 1808* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Utah: Ogden, June, 1871, *Coulter* (U. S. Nat. Herb.).

Nevada: grassy lowlands, Bieroth's Ranch, McDonald Creek, 2 Aug., 1912, *Nelson & Macbride 2159* (U. S. Nat. Herb.); East Humboldt Mountains, alt. 1985 m., U. S. Geol. Exploration of the 40th Parallel, *Watson 667* (Gray Herb. and U. S. Nat. Herb.).

Washington: eastern Washington, 26 July, 1892, *Henderson* (Mo. Bot. Gard. Herb.); Ellensburg, 2 June, 1897, *Whited 442* (U. S. Nat. Herb.); along streams, Mount Paddo (Adams), 30 June, 1885, *Suksdorf* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Falcon Valley, July, 1885, *Suksdorf 571* (Gray Herb.); without definite locality, coll. of 1883, *Brandegee* (Gray Herb.), and coll. of 1889, *Vasey 537* (U. S. Nat. Herb.).

Oregon: Crow Creek, Wallowa Co., alt. 1295 m., 3 July, 1897, *Sheldon 8512* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); on Miller Trail, near Sled Springs, Imnaha National Forest, alt. 1265 m., 12 July, 1907, *Jardine 89* (U. S. Nat. Herb.); Union Co., coll. of 1879, *Cusick 755* (Gray Herb.); Minum River, 16 Aug., 1897, *Sheldon 8710* (U. S. Nat. Herb.); Big Meadows, Des Chutes River, Crook Co., alt. 1370 m., 23 July, 1894, *Leiberg 515* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Crater Lake, 10 Aug., 1897, *Austin 1610* (U. S. Nat. Herb.); Cascade Mountains, Oregon Boundary Commission, coll. of 1860, *Lyall* (Gray Herb.); Brown's Meadow on Rogue River, alt. 1300 m., 8 July, 1889, *Leiberg 4287* (U. S. Nat. Herb.); without definite locality, U. S. Exploring Expedition, *Wilkes 494* (U. S. Nat. Herb. 48748).

California: Goose Lake Valley, July, 1895, *Austin 558* (U. S. Nat. Herb. 666887); Davis Creek, Modoc Co., Aug., 1894, *Austin* (Phil. Acad. Nat. Sci. Herb.); Upper Funston Meadows, basin of the Upper Kern River, Tulare Co., alt. 1980 m., July, 1904, *Hall & Babcock 5569* (Gray Herb.).

Var. **flavulus** (Greene) Greenm. comb. nov.

S. flavulus Greene, Pittonia **4**:108. 1900; Rydb. Bull. Torr. Bot. Club **27**:185. 1900; Fl. Colo. 397. 1906, in part.

S. Balsamitae Nels. in Coulter & Nelson, Manual Cent. Rocky Mountains 583. 1909, in part, not Muhl.

Stems slender, 1.5 to 4 dm. high; leaves relatively small, the radical and lower stem-leaves ovate-rotund to ovate-oblong, .8 to 4 cm. long, 8 to 20 mm. broad, rounded to acute at the apex, crenate to serrate-dentate, more or less cordate at the base; petioles 1 to 8.5 cm. long; upper stem-leaves petiolate and sublyrate or sessile and laciniate to entire.

Distribution: southern Wyoming and Colorado.

Specimens examined:

Wyoming: river bottoms, Encampment, Carbon Co., alt. 2175 m., 15 June, 1901, *Tweedy 4132* (U. S. Nat. Herb.).

Colorado: Walden, Larimer Co., 8 July, 1903, *Goodding 1494* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Sapinero, alt. 2285 m., 19 June, 1901, *Baker 176* (Gray Herb., U. S. Nat. Herb., Greene Herb., and Mo. Bot. Gard. Herb.); Black Cañon, alt. 2135 m., 12 June, 1901, *Baker 114* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Veta Pass, 15 July, 1896, *Shear 3592* (U. S. Nat. Herb.); Arboles, Archuleta Co., 15 June, 1899, *Baker 707* (Greene Herb., Berlin Herb., and Mo. Bot. Gard. Herb.), TYPE.

56. S. Burkei Greenm. Ottawa Nat. **25**:114. 1911; Ann. Mo. Bot. Gard. **2**:626, *pl. 20, fig. 1.* 1915.

An herbaceous perennial, glabrous or nearly so; stems erect, 3 to 9 dm. high, simple or rarely branched, striate; lower leaves petiolate, ovate-oblong, 1 to 7 cm. long, 1 to 3.5 cm. broad, obtuse or rounded at the apex, crenate to serrate-dentate, cuneate to subtruncate at the base; petioles 2 to 12 cm. long; stem-leaves petiolate and sublyrate to sessile and pinnatisect; inflorescence a terminal few to many-headed corymbose cyme; heads 10 to 12 mm. high, radiate; involucre campanulate, calyculate; bracts of the involucre usually 21, linear-lanceolate, 6 to 8 mm. long, glabrous or floccose-tomentulose, more or less tinged with purple; ray-flowers about 12, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: Minnesota to British Columbia.

Specimens examined:

Minnesota: Itaska Lake, 25 June, 1891, *Sandberg 1036* (U. S. Nat. Herb.).

Montana: Glacier National Park, 9 July, 1914, *Hitchcock 11831* (U. S. Nat. Herb.); open ground, shore of Lake McDonald, alt. 950 m., 25 July, 1901, *Vreeland* (U. S. Nat. Herb. and Geol. Surv. Canada Herb.); Columbia Falls, 1 July, 1894, *Williams 68* (U. S. Nat. Herb.).

Idaho: wet soil, Kootenai Co., alt. 650 m., *Leiberg* (Mo. Bot. Gard. Herb.).

Rocky Mountains: Grand Saline, "R. M. E. side", *Burke* (Gray Herb.), TYPE; river margins, Silver City, 7 Aug., 1885, *Macoun* (Gray Herb. and Geol. Surv. Canada Herb. 14772); swamps, Kicking Horse Lake, alt. 1540 m., 10 Aug., 1890, *Macoun* (Geol. Surv. Canada Herb. 14810).

Alberta: bank of Bow River, vicinity of Banff, alt. 1370 m., 20 July, 1899, *McCalla 2045* (U. S. Nat. Herb.); by the reservoir, Banff, 30 Oct., 1899, *Sanson* (Geol. Surv. Canada Herb. 22288); in vicinity of Banff, July, 1906, *Sanson* (Geol. Surv. Canada Herb. and Field Mus. Herb.); Banff, 28 July, 1904, *Farr* (Field Mus. Herb.); northern slopes of Crows Nest Pass, 31 July, 1887, *Macoun* (Geol. Surv. Canada Herb. 22785), in part.

British Columbia; open thicket, Spence's Bridge, 31 May, 1889, *Macoun* (Geol. Surv. Canada Herb. 14811), in part; cleared land at Homer Lake, 19 June, 1905, *Shaw 722* (Phil. Acad. Nat. Sci. Herb. and Mo. Bot. Gard. Herb.); Sophie Mountain, between Kettle and Columbia Rivers, 17 July, 1902, *Macoun 64990, 64991* (Gray Herb. and Geol. Surv. Canada Herb.); Skagit Valley, alt. 760–925 m., 21 Aug., and 10 July, 1905, *Macoun 69358, 69359* (Gray Herb. and Geol. Surv. Canada Herb.); shaded banks, mouth of Silica Creek, Chilliwack River, 29 June, 1901, *Macoun 26685* (Geol. Surv. Canada Herb., Greene Herb., and Gray Herb.), in part; on a bog, Chilliwack Lake, 19 July, 1901, *Macoun 26682, 26682a* (Geol. Surv. Canada Herb.); in a marsh east of Chilliwack Lake, 25

July, 1901, *Macoun* (Geol. Surv. Canada Herb., Gray Herb., and Mo. Bot. Gard. Herb.); Middle Creek, Chilliwack River, 2 Aug., 1901, *Macoun 26681* (Geol. Surv. Canada Herb. and Greene Herb.); in thicket by stream at 150-mile house, Cariboo, 15 July, 1900, *Wilson 700* (Geol. Surv. Canada Herb.).

57. S. gaspensis Greenm.[1]

An herbaceous perennial, commonly lightly floccose-tomentulose in the axils of the leaves; stems one to several from a common base, erect, 2.5 to 5 dm. high; lower leaves petiolate, broadly ovate to elliptic-lanceolate, .5 to 8 cm. long, 1 to 3.5 cm. broad, thin, glabrous on both surfaces, or sometimes in the early stages sparingly hairy, especially on the under surface, glabrate, rounded to obtuse at the apex, crenate-dentate, abruptly narrowed at the base into a slender petiole 1 to 12 cm. in length; inflorescence a terminal several-headed corymbose cyme; involucre campanulate, calyculate, glabrous or slightly pubescent; bracts of the involucre 13 to 21, linear-lanceolate, 4 to 6 mm. long; ray-flowers 8 to 12, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: Newfoundland, eastern Quebec, and northern Maine.

Specimens examined:

Newfoundland: meadow and damp talus on hill north of Tilt Cove, Notre Dame Bay, 22 Aug., 1911, *Fernald & Wiegand 6405* (Gray Herb.).

Quebec: cold walls of Percé Mountain, Percé, Gaspé Co., 25 July, 1905, *Williams, Collins & Fernald* (Gray Herb.),

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[1]**Senecio gaspensis** Greenm. sp. nov., herbaceus perennis ad basin et in axillis foliorum plerumque albo-flocculoso-tomentulosus; caulibus erectis 2.5–5 dm. altis; foliis inferioribus petiolatis late ovatis vel elliptico-lanceolatis .5–8 cm. longis 1 to 3.5 cm. latis membranaceis utrinque glabris vel juventa subtus sparse pubescentibus denique glabratis, ad apicem rotundatis vel obtusis, crenato-dentatis, ad basin abrupte contractis; petiolis gracilibus 1–12 cm. longis; inflorescentiis corymboso-cymosis terminalibus; capitulis 7–10 mm. altis, radiatis; involucris campanulatis glabris vel parce pubescentibus; bracteis involucri 13–21 lineari-lanceolatis 4–6 mm. longis; floribus femineis 8–12 ligulatis, ligulis flavibus; floribus disci numerosis longioribus quam squamae involucri; achaeniis glabris.—On cold walls of Percé Mountain, Percé, Gaspé Co., Quebec, 25 July, 1905, *Williams, Collins & Fernald* (Gray Herb.), TYPE; Grand Coupe, Percé, and Bonaventure Island, Gaspé Co., Aug., 1907, *Fernald & Collins 1204, 1205* (Gray Herb.); between the Forks and Brûlé Brook, Little Cascapedia River, Bonaventure Co., 29, 30 July, 1904, *Collins, Fernald & Pease* (Gray Herb. and U. S. Nat. Herb.); shaded alluvium, Fort Kent, Maine, 6 July, 1904, *Fernald* (Gray Herb.).

TYPE; cold northerly calcareous walls of the Grand Coupe, Percé, Gaspé Co., 6 Aug., 1907, *Fernald & Collins 1204* (Gray Herb.); limestone cliffs, Bonaventure Island, Gaspé Co., 7 Aug., 1907, *Fernald & Collins 1205* (Gray Herb.); alluvial thickets, between the Forks and Brûlé Brook, Little Cascapedia, *Collins, Fernald & Pease* (Gray Herb. and U. S. Nat. Herb.).

Maine: shaded alluvium, Fort Kent, 6 July, 1904, *Fernald* (Gray Herb.); rocky river flat, Fort Kent, 10 July, 1908, *Mackenzie 3418* (U. S. Nat. Herb. 648722).

58. S. Crawfordii Britt. Torreya **1**:21. 1901; Manual 1027. 1901, and ed. 2, 1905; Britton & Brown, Ill. Fl. **3**:545, *fig. 4628.* 1913.

S. Balsamitae var. *Crawfordii* (Britt.) Greenm. in Rhodora **10**:69. 1908, and in Gray, Manual, ed. 7, 854. 1908.

An herbaceous perennial, glabrous throughout or slightly tomentose on the base of the petioles and in the leaf-axils; stems erect, 3 to 6 dm. high; lower leaves long-petiolate, ovate to elliptic-lanceolate, the blades 1 to 8 cm. long, 1 to 3.5 cm. broad, rounded or obtuse at the apex, crenate to serrate-dentate, usually abruptly narrowed at the base, glabrous on both surfaces; petioles slender, 2 to 18 cm. long; stem-leaves petiolate and more or less lyrate to sessile and incised-serrate; inflorescence a few-headed corymbose cyme; heads about 1 cm. high, radiate; involucre campanulate, calyculate; bracts of the involucre 13 to 21, narrowly lanceolate, 6 to 8 mm. long, acute, glabrous, often purplish-tipped; ray-flowers 8 to 12, rays yellow, conspicuous; disk-flowers numerous; achenes glabrous.

Distribution: western New Jersey and southeastern Pennsylvania.

Specimens examined:

New Jersey: Assinipink Creek, near Trenton and New Brunswick trolley bridge, 28 May, 1904, *Brown* (Phil. Acad. Nat. Sci. Herb.); Abbott's meadow, below Trenton, 29 May, 1904, *Brown* (Phil. Acad. Nat. Sci. Herb.); Crosswick's Creek, 29 May, 1904, *Williamson* (C. S. Williamson Herb.); wet meadow between Springdale and Orchard, Camden Co., 20 May, 1905, *Stone* (Phil. Acad. Nat. Sci. Herb.).

Pennsylvania: in low wet ground, Tullytown, Bucks Co., 12 May, 1894, *MacElwee* (Phil. Acad. Nat. Sci. Herb.); swamp, near Tullytown, 20 May, 1899, *Fretz* (Phil. Acad. Nat. Sci. Herb.); Tullytown, 30 May, 1899, and 22 May, 1900, *Crawford* (Phil. Acad. Nat. Sci. Herb.); Tullytown, May, 1902, *Crawford & Brown* (Phil. Acad. Nat. Sci. Herb.); wet places in bog near Willow Grove, Montgomery Co., 25 May, 1899, *MacElwee 326* (Phil. Acad. Nat. Sci. Herb.); Fraser's bog, east of Willow Grove, 20 May, 1906, *Williamson* (Phil. Acad. Nat. Sci. Herb.); Fraser's bog, one mile southeast of Willow Grove, 17 and 23 June, 1902, *Van Pelt* (Phil. Acad. Nat. Sci. Herb.), form; Fraser's bog, near Bayer's Corner, 12 May, 1910, *Long 3307* (Phil. Acad. Nat. Sci. Herb.); near Philadelphia, 29 May, 1901, *Crawford* (Gray Herb.).

59. **S. quaerens** Greene, Leafl. Bot. Obs. & Crit. **1**:214. 1906; Wooton & Standley, Contr. U. S. Nat. Herb. **19**:747. 1915.

S. prionophyllus Greene, Leafl. Bot. Obs. & Crit. **1**:212. 1906, not *S. prionophyllus* Greene, Ottawa Nat. **15**:250. 1902.

An herbaceous perennial, glabrous or slightly white-floccose-tomentulose, especially towards the base of the stem, on the petioles, and in the leaf-axils; stems erect, 3 to 6 dm. high, rather leafy at the base, nearly naked above; lower leaves petiolate, subobovate to ovate-oblong, 1 to 8 cm. long, 1 to 3 cm. broad, rounded to obtuse at the apex, crenate to subserrate-dentate; petioles 1.5 to 14 cm. long; stem-leaves petiolate and sublyrate to sessile and more or less pinnatisect; inflorescence a one to many-headed corymbose cyme; heads about 1 cm. high, radiate; involucre campanulate, sparingly calyculate, slightly tomentulose at the base; bracts of the involucre linear-lanceolate, 5 to 7 mm. long, acute; ray-flowers 8 to 12, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: mountains of New Mexico.

Specimens examined:

New Mexico: moist places on the west fork of the Gila River, Mogollon Mountains, Socorro Co., alt. about 2285 m., 7 Aug., 1903, *Metcalfe 409* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.), TYPE; Willow Creek, Mogollon Mountains,

Socorro Co., 8 Aug., 1900, *Wooton* (U. S. Nat. Herb.); Santa Magdalena Mountains, June, 1881, *Vasey* (U. S. Nat. Herb.).

60. S. platylobus Rydb. Bull. Torr. Bot. Club **27**:181, *pl. 6, fig. 8.* 1900.

An herbaceous perennial, glabrous or essentially so; stems erect, 2.5 to 4 dm. high, striate; lower leaves petiolate, obovate or broadly oval, including the petiole 3.5 to 14 cm. long, 1 to 3 cm. broad, irregularly dentate; stem-leaves petiolate and sublyrate to sessile and pinnately divided into oblong to cuneate, rather conspicuous, rounded or acute lateral divisions; inflorescence a many-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre 13 to 21, lanceolate, acute, 5 to 6 mm. long, glabrous, somewhat stramineous; ray-flowers 10 to 12, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: mountains of Utah.

Specimens examined:

Utah: Wasatch Mountains, coll. of 1869, *Watson 671* (Torrey Herb.), TYPE; cañon bottoms, Provo, Wasatch Mountains, 16 June, 1902, *Goodding 1115* (Mo. Bot. Gard. Herb.); Red Rock Cañon, near Salt Lake City, 11 June, 1905, *Rydberg 6064* (U. S. Nat. Herb.); rich woods in mountain cañon, *Armstrong 336* (Margaret Armstrong Herb.); Mendon, 17 June, 1898, *Mulford 124* (Mo. Bot. Gard. Herb.).

There appears to have been some confusion of the material which was distributed by Dr. Watson under his number 671. The specimen in the United States National Herbarium agrees very well, particularly in habit and foliar characters, with typical forms of *S. crocatus,* but it differs markedly from Watson's 671 in the Gray Herbarium (which is apparently *S. rubricaulis* Greene) and likewise from the specimen bearing the same number in the Torrey Herbarium, namely the type of *S. platylobus* Rydb.

61. S. crocatus Rydb. Bull. Torr. Bot. Club **24**:299. 1897; *ibid.* **27**:177. 1900, in part; Mem. N. Y. Bot. Gard. **1**:446. 1900, at least as to synonymy; Fl. Colo. 396. 1906, in part; Greene,

Pittonia **4**:114. 1900; Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains 582. 1909, in part; Daniels, Univ. Mo. Studies, Sci. Ser. **2**:252. 1911, in part.

S. aureus L.? var. *croceus* Gray, Proc. Acad. Nat. Sci. Phil. **15**:68. 1863, i. e., Hall and Harbour No. 332, in part, and Parry No. 405, not *S. croceus* DC.

S. aureus var. *croceus* Gray, Syn. Fl. N. Am. **1**^{2}:391. 1884, and ed. 2, 1886, in part.

S. longipetiolatus Rydb. Bull. Torr. Bot. Club **27**: 176. 1900; Fl. Colo. 396. 1906; Coulter & Nelson, Manual Cent. Rocky Mountains 582. 1909.

S. Tracyi Rydb. Bull. Torr. Bot. Club **33**:159. 1906; Fl. Colo. 397. 1906.

S. pyrrhochrous Greene, Pl. Baker. **3**:24. 1901.

An herbaceous perennial, glabrous throughout or slightly tomentulose in the axils of the bracts of the inflorescence; stems erect, 1 to 7.5 dm. high from a rather stout rootstock, striate; lower leaves petiolate, oblong-ovate, subcordate to abruptly contracted at the base, rounded, obtuse or submucronate at the apex, entire to somewhat crenate-dentate; petioles 1 to 12 cm. long; stem-leaves petiolate and sublyrate to sessile and semiamplexicaul; inflorescence a few to many-headed corymbose cyme; heads in anthesis 8 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre (13–) 21, linear-lanceolate, 5.5 to 8 mm. long, acute, glabrous, more or less tinged with purple; ray-flowers 10 to 12, rays orange-red or saffron-colored varying to yellow; disk-flowers numerous; achenes glabrous.

Distribution: mountains of Colorado and Utah.

Specimens examined:

Colorado: Medicine Bow Mountains, 3 Aug., 1891, *Crandall* (U. S. Nat. Herb.); Rocky Mountain Flora, Lat. 39–41°, coll. of 1862, *Hall & Harbour 332* (Gray Herb.), in part, TYPE; Middle Park, coll. of 1862, *Parry 405* (Gray Herb., Mo. Bot. Gard. Herb., and U. S. Nat. Herb. 349244); without definite locality, *Wolf & Rothrock 581* (Gray Herb., U. S. Nat. Herb., and Phil. Acad. Nat. Sci. Herb.); Gray's Peak, July, 1888,

Eastwood (U. S. Nat. Herb.); Park Co., *Williamson* (C. S. Williamson Herb.); Dickey, below Breckenridge, 2 Sept., 1885, *ex Herb. Fritchey* (Mo. Bot. Gard. Herb.); near Breckenridge, coll. of 1892, *Wislizenus 1086,* and Aug., 1901, *Mackenzie 211* (Mo. Bot. Gard. Herb.); Mt. Baldy, 15 July, 1906, *Anderson* (Mo. Bot. Gard. Herb.); vicinity of Twin Lakes, 2 Aug., 1873, *Coulter* (Phil. Acad. Nat. Sci. Herb.); Mt. Lincoln, alt. 3650 m., 9 July, 1873, *Coulter* (U. S. Nat. Herb.); Weston's Pass, 18 July, 1873, *Coulter* (U. S. Nat. Herb.); damp meadows, Elk Mountains, coll. of 1881, *Brandegee* (Mo. Bot. Gard. Herb.); Jack's Cabin, Gunnison Co., alt. 2520 m., 26 Aug., 1901, *Baker 612* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); vicinity of Mount Carbon, Gunnison Co., alt. 2750 m., 6 July, 1910, *Eggleston 5866* (U. S. Nat. Herb.); Marshall Pass, 27 July, 1896, *Shear 5162* (U. S. Nat. Herb.); Sargents, Saguache Co., alt. 2580 m., 5 July, 1901, *Baker 348* (Gray Herb., U. S. Nat. Herb., Greene Herb., and Mo. Bot. Gard. Herb.); Silverton, 5 Aug., 1897, *Shear 4900* (U. S. Nat. Herb.); Hamor's Lake, north of Durango, alt. 2740 m., 24 July, 1898, *Baker, Earle & Tracy 625* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.).

Utah: Wasatch Mountains, alt. 1525 m., May, 1869, *Watson 671* (U. S. Nat. Herb.); Fish Lake, National Forest, alt. 2925 m., 19 July, 1913, *Arriveé* (U. S. Nat. Herb.).

Var. **Wolfii** Greenm. comb. nov.

S. Wolfii Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

Stems slender, 2 to 3 dm. high; lower leaves ovate-rotund to ovate-oblong, 7 to 20 mm. long, 5 to 13 mm. broad, rounded or obtuse at the apex, entire, subcordate to cuneate at the base. Similar to the species but somewhat more slender and with smaller leaves.

Distribution: mountains of Colorado.

Specimens examined:

Colorado: South Park, Lieut. Wheeler's Expedition, 1873, *Wolf & Rothrock 582, 586* (Gray Herb. and U. S. Nat. Herb.), TYPE; meadows, South Cottonwood Gulch, Chaffee Co., alt. 3050 m., 9 July, 1892, *Sheldon 481* (U. S. Nat. Herb.).

62. S. aquariensis Greenm.[1]

An herbaceous perennial, glabrous or slightly tomentulose in the inflorescence; stems erect, solitary or closely cespitose, 2 to 3.5 dm. high; lower leaves petiolate, ovate to oblong-lanceolate, 1 to 7 cm. long, .5 to 2 cm. broad, obtuse to acute, entire, glabrous on both surfaces; petioles 1 to 6 cm. long; stem-leaves petiolate and sublyrate to sessile, semiamplexicaul and more or less pinnatisect; inflorescence a terminal rather close corymbose cyme; heads numerous, 8 to 10 mm. high, sparingly calyculate, radiate; involucre campanulate; bracts of the involucre 13 (–21), lanceolate, 5 to 6 mm. long, acute, glabrous; ray-flowers 10 to 12, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: high plateaus of Utah.

Specimens examined:

Utah: Aquarius Plateau, alt. 3050 m., 5 Aug., 1875, *Ward 505* (Mo. Bot. Gard. Herb., Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Field Mus. Herb.), TYPE; Bear River Valley, coll. of 1877, *Palmer 267½* (Gray Herb., U. S. Nat. Herb. 782529 in part, and Mo. Bot. Gard Herb.).

63. S. dimorphophyllus Greene, Pittonia **4**:109. 1900; Rydb. Bull. Torr. Bot. Club **27**:178. 1900; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

S. heterodoxus Greene ex Rydb. Bull. Torr. Bot. Club **27**:178. 1900; Fl. Colo. 396. 1906, in synonymy.

S. aureus var. *croceus* Gray, Proc. Acad. Nat. Sci. Phil. **15**:68. 1863, i. e., Hall & Harbour No. 332, in part; Gray, Syn. Fl. N. Am. **1**[2]:391. 1884, and ed. 2, 1886, in part; Porter &

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[1]**Senecio aquariensis** Greenm. sp. nov., herbaceus perennis glabrus vel in inflorescentiis leviter tomentosus; caulibus erectis 2–3 dm. altis solitariis vel dense caespitosis; foliis inferioribus petiolatis ovatis vel oblongo-lanceolatis 1–7 cm. longis .5–2 cm. latis obtusis vel acutis integris vel paulo dentatis utrinque glabris ad basin abrupte cuneatis vel raro subcordatis; petiolis 1–6 cm. longis; foliis superioribus petiolatis et sublyratis vel sessilibus plus minusve pinnatisectis semiamplexicaulibusque; inflorescentiis terminalibus conferte corymboso-cymosis; capitulis numerosis 8–10 mm. altis parce calyculatis radiatis; involucris campanulatis; bracteis involucri 13 (–21) lanceolatis 5–6 mm. longis acutis glabris; floribus femineis 10–12, ligulis flavibus; floribus disci numerosis; achaeniis glabris.—Collected on the Aquarius Plateau, alt. 3050 m., 5 Aug., 1875, *Ward 505* (Mo. Bot. Gard. Herb., Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Field Mus. Herb.); Bear River Valley, coll. of 1877, *Palmer 267½* (Gray Herb., U. S. Nat. Herb. 782529 in part, and Mo. Bot. Gard. Herb.).

Coulter, Syn. Fl. Colo. 82. 1874, in part; Coulter, Manual Rocky Mountain Region 211. 1885, in part.

S. crocatus Rydb. Mem. N. Y. Bot. Gard. **1**:446. 1900, in part; Bull. Torr. Bot. Club **27**:177, *pl. 5, fig. 13.* 1900, as to description, illustration, and most of specimens cited, not as to synonymy; Fl. Colo. 396. 1906, mainly; Daniels, Fl. Boulder 252. 1911, mainly; Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains 582. 1909, in part.

An herbaceous perennial, glabrous or essentially so throughout; stems one to several from a common base, erect or ascending, 1 to 3 dm. high; lower leaves ovate, subobovate, broadly spatulate or somewhat oblong-lanceolate, 1 to 4 cm. long, .5 to 2.5 cm. broad, rounded to obtuse at the apex, entire to crenate, narrowed at the base into a winged petiole equalling or exceeding the blade; stem-leaves mostly sessile, oblong-lanceolate to triangular-ovate, frequently conspicuously dilated at the base and amplexicaul; inflorescence a few to several-headed terminal corymbose cyme; heads about 1 cm. high, radiate; involucre campanulate, calyculate; bracts of the involucre about 21, linear-lanceolate, 6 to 7 mm. long, acuminate, acute, glabrous or slightly tomentulose, frequently reddish-tipped; ray-flowers 10 to 12, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: mountains of Wyoming and Colorado.

Specimens examined:

Wyoming: La Plata Mines, 21 Aug., 1895, *A. Nelson 1769* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); wet, subalpine woods, Nash's Fork, Albany Co., 15 Aug., 1908, *A. Nelson 9148* (Mo. Bot. Gard. Herb.); grassy ground, below snow, Bridges Peak, Carbon Co., 24 Aug., 1903, *Goodding 1980* (U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.).

Colorado: alpine meadows, summit of North Park Range, Larimer Co., 10 Aug., 1903, *Goodding 1820* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); about timberline, above Berthoud's Pass, 14 Sept., 1874, *G. Engelmann* (Mo. Bot. Gard. Herb.); timberline, Long's Peak, 5 Aug., 1886, *Letterman*

(Mo. Bot. Gard. Herb.); foot of Kelso Mountain, near Torrey's Peak, 14 Aug., 1885, *Letterman* (Mo. Bot. Gard. Herb.); Front Range, alt. 3500 m., 6 July, 1896, *Crandall* (Mo. Bot. Gard. Herb.); Grays Peak, above timberline, 31 Aug., 1884, *B. H. Smith* (Phil. Acad. Nat. Sci. Herb.); Grays Peak, alt. 3650–3800 m., 15 Aug., 1885, *Letterman* (Mo. Bot. Gard. Herb. and Field Mus. Herb.); Powell's Colorado Expl. Exp., 1868, Lat. 40–41°, *Vasey 340B* (Gray Herb. and Mo. Bot. Gard. Herb.); Lat. 39–41°, coll. of 1862, *Hall & Harbour 332* (U. S. Nat. Herb. 48721, Phil. Acad. Nat. Sci. Herb., and Field Mus. Herb. 314668); Lat. 39–41°, coll. of 1862, *Hall & Harbour 331* (U. S. Nat. Herb. 48766), in part, and *Hall & Harbour 115* (Gray Herb.), in part; without definite locality, coll. of 1871, *Brandegee 132* (Mo. Bot. Gard. Herb.); Breckenridge, coll. of 1892, *Wislizenus 1067* (Mo. Bot. Gard. Herb.); Mt. Parry, coll. of 1872, *Gray* (Gray Herb.); Golden City, 12 July, 1871, *Greene 528* (Gray Herb.); Golden, 13 July, 1885, *Letterman* (Mo. Bot. Gard. Herb.); Peak Valley, 21 Aug., 1901, *F. E. & E. S. Clements 485* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Cameron Pass, alt. 3500 m., 14 July, 1896, *Baker* (Mo. Bot. Gard. Herb.); meadows, South Cottonwood Gulch, Chaffee Co., alt. 3050 m., 9 July, 1892, *Sheldon 100* (U. S. Nat. Herb.); Gunnison Co., July, 1889, *Eastwood* (U. S. Nat. Herb.); Mineral Point, July, 1887, *Hempton* (Mo. Bot. Gard. Herb.); near Pagosa Peak, Mineral Co., alt. 3200 m., 6 Aug., 1899, *Baker 705* (Gray Herb., Berlin Herb., Greene Herb., and Mo. Bot. Gard. Herb.), TYPE; head of Vallecito, alt. 3000–3800 m., 2 Sept., 1903, *Knowlton 3* (U. S. Nat. Herb.); La Plata Mountains, alt. 3650 m., 15 July, 1896, *Tweedy 537* (U. S. Nat. Herb.); Little Kate Mine, La Plata Mountains, alt. 3500 m., 14 July, 1898, *Baker, Earle & Tracy 569* (Gray Herb., U. S. Nat. Herb., Greene Herb., and Mo. Bot. Gard. Herb.), TYPE of *S. heterodoxus* Greene; Farnham, 10 July, 1891, *E. C. Smith* (Mo. Bot. Gard. Herb.).

64. S. Farriae Greenm. Bot. Gaz. **42**:147. 1906; Contr. Bot. Lab. Univ. Penn. **3**:74. 1907; Ottawa Nat. **25**:115. 1911.

An herbaceous perennial, glabrous except for a persistent white tomentum in the axils of the leaves; stems erect or as-

cending, 1 to 3 dm. high, simple or branched from near the base; lower leaves ovate to slightly obovate, the blade 1 to 4 cm. long, 1 to 2.5 cm. broad, rounded at the apex, crenate to subentire, contracted at the base into a narrowly winged petiole equalling or exceeding the blade; stem-leaves petiolate and sublyrate to sessile and somewhat irregularly pinnatifid, the uppermost leaves reduced to mere bracts; heads about 1 cm. high, radiate; involucre campanulate, slightly calyculate, sparingly tomentulose at the base; bracts of the involucre about 21, linear-lanceolate, 7 to 8 mm. long, frequently reddish-tipped; ray-flowers 10 to 14, rays yellow; disk-flowers numerous, 50 to 60; achenes glabrous.

Distribution: mountains of Alberta to Washington.

Specimens examined:

Alberta: near Banff, alt. 1500 m., 8 June, 1904, *Farr* (Univ. Penn. Herb. and Field Mus. Herb.), TYPE; vicinity of Banff, July, 1906, *Sanson 81260* (Geol. Surv. Canada Herb. and Mo. Bot. Gard. Herb.); vicinity of Basin, near Banff, alt. 1400 m., 8 and 18 June, 1906, *Brown 20* (Phil. Acad. Nat. Sci. Herb.); in deep moss in stream-bed below warm sulphur spring, vicinity of Banff, alt. 1370 m., 15 June, 1899, *McCalla 2049* (U. S. Nat. Herb.); Sulphur Springs, Banff, alt. 1415 m., 11 June, 1906, *Butters & Rosendahl 1324* (Field Mus. Herb.); Crows Nest Lake, alt. 1385 m., 9 July, 1883, *Dawson* (Geol. Surv. Canada Herb. 14800), in part; Devil's Head Lake, alt. 1385 m., 13 July, 1899, *Sanson* (Geol. Surv. Canada Herb. 22125); crossing of McLeod's River, 19 June, 1898, *Spreadborough* (Geol. Surv. Canada Herb. 19725); in grass along Bragg's Creek, Elbow River, 26 June, 1897, *Macoun* (Geol. Surv. Canada Herb. 22784); damp places, Red Deer, coll. of 1895, *Gaetz* (Geol. Surv. Canada Herb. 11622).

Washington: on rocky bar of Columbia River at Wenatchee, 25 May, 1899, *Whited 1096* (U. S. Nat. Herb.).

65. S. Hartianus Heller, Bull. Torr. Bot. Club **26**:622. 1899.

S. flavulus Wooton & Standley, Contr. U. S. Nat. Herb. **19**:747. 1915, in part, not Greene.

An herbaceous perennial, at first somewhat white-tomentulose, later more or less glabrate; stems erect, 2 to 5 dm. high,

lower leaves petiolate, ovate-rotund, ovate-oblong to subobovate, 1 to 3.5 cm. long, .5 to 2 cm. broad, rounded to obtuse at the apex, minutely crenate to serrulate, subcordate to abruptly contracted to a cuneate base; petioles 1 to 6.5 cm. long; inflorescence a few to many-headed corymbose cyme; heads 6 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate, tomentulose; bracts of the involucre 13 to 21, linear, 4 to 6 mm. long; ray-flowers about 12, rays pale yellow; disk-flowers numerous; achenes glabrous.

Distribution: mountains of New Mexico and Arizona.

Specimens examined:

New Mexico: Winsor's Ranch, Pecos River National Forest, alt. 2500 m., 30 June, and 3 July, 1908, *Standley 4058, 4061, 4165* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); marsh, Kingston, Sierra Co., alt. 2000 m., 25 May, 1904, *Metcalfe 931* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Arizona: vicinity of Flagstaff, alt. 2135 m., 5 July, 1898, *MacDougal 230* (Gray Herb. and Phil. Acad. Nat. Sci. Herb.), TYPE; San Francisco Mountains, 7 July, 1892, *Toumey 663* (Gray Herb. and U. S. Nat. Herb.); San Francisco Mountains, 21 Aug., 1889, *Knowlton 64* (U. S. Nat. Herb.); Mt. Agassiz, coll. of 1884, *Lemmon 3283* (Gray Herb.); near Kendrick Mountains, alt. 2000 m., 7 July, 1901, *Leiberg 5663* (U. S. Nat. Herb.); Cooley's Ranch, Navajo Co., 1 July, 1912, *Goodding 1108* (U. S. Nat. Herb.).

66. S. plattensis Nutt. Trans. Am. Phil. Soc. N. S. **7**:413. 1841; Britton & Brown, Ill. Fl. **3**:478, *fig. 4039*. 1898, and ed. 2, 543, *fig. 4623*. 1913; Heller, Cat. N. Am. Pl. 146. 1898, and ed. 2, 230. 1900; Rydb. Mem. N. Y. Bot. Gard. **1**:445. 1900, and Bull. Torr. Bot. Club **27**:185, *pl. 6, fig. 14*. 1900; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Britton, Manual 1026. 1901, and ed. 2, 1905; Rydb. Fl. Colo. 396. 1906; Coulter & Nelson, Manual Cent. Rocky Mountains 581. 1909; Daniels, Univ. Mo. Studies, Sci. Ser. **2**:251. 1911.

S. balsamitae Torr. in Nicollet's Report, App. B, 153 [237]. 1843, not Muhl.

S. aureus var. *Balsamitae* Torr. & Gray, Fl. N. Am. **2**:442. 1843, in part; Gray in Boston Jour. Nat. Hist. **6**:231. 1857; Gray, Syn. Fl. N. Am. **1**[2]:391. 1884, and ed. 2, 1886, in part.

S. camporum Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

S. pseudotomentosus Mack. & Bush, Trans. Acad. Sci. St. Louis **12**:88, *pl. 17*. 1902.

An herbaceous perennial, usually more or less persistently white-floccose-tomentulose, rarely glabrous throughout; stems erect, one to several from a common base, 1 to 4 dm. high; leaves variable, the lower ovate-oblong to lanceolate or somewhat oblanceolate, 1 to 8 cm. long, .5 to 4 cm. broad, rounded to obtuse at the apex, crenate to serrate-dentate, subcordate to gradually narrowed at the base; petioles 1 to 15 cm. long; stem-leaves petiolate and sublyrate to sessile and very irregularly pinnatisect; inflorescence a terminal corymbose cyme; heads usually numerous, 8 to 10 mm. high, radiate; involucre campanulate, calyculate; bracts of the involucre 13 (–21), linear-lanceolate, 5 to 6 mm. long, glabrous or slightly tomentulose, penicillate; ray-flowers 10 to 12, rays yellow; disk-flowers numerous; achenes usually hispidulous along the angles, sometimes glabrous.

Distribution: southwestern Ontario to Saskatchewan and eastern Montana, south to Louisiana and Texas.

Specimens examined:

Ontario: on sand dunes, Port Franks, Lambton Co., 24 May, 1906, and 9 Aug., 1907, *Dodge 298, 108* (U. S. Nat. Herb.); Camlachie, 18 June, 1901, *Macoun* (Gray Herb. and U. S. Nat. Herb.); northeast of Sarnia, 5 June, 1897, *Dodge 297* (U. S. Nat. Herb.).

Manitoba: Stony Mountain, 14 June, 1887, *Fowler* (Mo. Bot. Gard. Herb.); open places south of Sewell, 12 June, 1876, *Macoun 12232* (Geol. Surv. Canada Herb.); gravelly or rocky places, Fort Ellice, 20 June, 1879, *Macoun 14799* (Geol. Surv. Canada Herb.).

Saskatchewan: Long Lake (Last Mountain Lake), 6 July, 1879, *Macoun 48* (Gray Herb.).

Michigan: dry fields and dryish woods, near Rochester, 2 June, 1912, and 25 May, 1913, *Farwell 2616, 3383, 3394* (Mo. Bot. Gard. Herb.); sterile hills, and in marl beds, Parkdale Farm, 2 June, 1912, 25 May, and 8 June, 1913, and 30 May, 1914, *Farwell 2608, 3414, 3443, 3655* (Mo. Bot. Gard. Herb.); dry soil in oak openings, Grand Rapids, 12 June, 1893, *Cole* (Gray Herb.); without definite locality, coll. of 1902, *H. L. Clark* (U. S. Nat. Herb. 413298).

Indiana: Notre Dame, 2 June, 1908, *Nieuwland,* and 14 May, 1913, *Nieuwland 11079* (Mo. Bot. Gard. Herb.).

Wisconsin: Fort Howard, on beaver dam, 15 June, 1878, *Schuette* (U. S. Nat. Herb. and Field Mus. Herb.).

Illinois: gravelly bluffs, Ringwood, coll. of 1860, *Vasey* (Gray Herb.); moist prairie, near Wady Petra, 20 May, 1896, *Chase* (Mo. Bot. Gard. Herb.); dry gravelly soil, Peoria, May and June, 1904, *McDonald* (Gray Herb.); vicinity of Oquawka, *Patterson* (Gray Herb. and Field Mus. Herb.); Mississippi River valley opposite St. Louis, 13 May, 1874, *Eggert* (Gray Herb., U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); dry hills, French Village, 14 May, 1875, 14 May, 1878, and 8 May, 1892, *Eggert* (Mo. Bot. Gard. Herb.); French Village, 23 April, 1878, *Eggert* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); French Village, 17 May, 1894, *Glatfelter* (Mo. Bot. Gard. Herb.); bluffs, near Belleville, April, 1834, (?) *Engelmann 592* (Mo. Bot. Gard. Herb.); without definite locality, *Brendel* (Berlin Herb. and Gray Herb.).

Missouri: Windsor Springs, 26 April, 1890, *Hitchcock* (Mo. Bot. Gard. Herb.); Cliff Cave, 3 May, 1901, *J. H. Kellogg* (Mo. Bot. Gard. Herb.); Kimmswick, 10 May, 1885, *Wislizenus 226* (Mo. Bot. Gard. Herb.), in part; Kimmswick, 9 May, 1915, *Drushel 1262* (Mo. Bot. Gard. Herb. and J. A. Drushel Herb.); sandy rocks, near Crystal City, 20 May, 1887, *Eggert* (Mo. Bot. Gard. Herb.); Potosi, 3 June, 1892, *Dewart 96* (Mo. Bot. Gard. Herb.); dry ground, near Bismarck, 30 April, 1893, *Eggert* (Mo. Bot. Gard. Herb.); Monteer, 24 May, 1900, 13 May, 1901, 2 May, 1902, and 27 April, 1907, *Bush 711, 455, 1487* and *4338* (Mo. Bot. Gard. Herb.); Grandin, 5 May, 1901, *Bush 344* (Mo. Bot. Gard. Herb.); Grandin, 6 May, 1905,

Bush 2706, 2706A (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Butler Co., 1 May, 1905, *Bush 2558* (Mo. Bot. Gard. Herb.); Pleasant Grove, 20 May, 1900, *Bush 336* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Pleasant Grove, 21 May, 1900, *Bush 363* (Mo. Bot. Gard. Herb.); Jerome, 28 April, 1914, *J. H. Kellogg 453* (Mo. Bot. Gard. Herb.); Springfield, 28 April, 1888, *Weller 683* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Watson, 1 June, 1894, *Bush 180* (Gray Herb. and Mo. Bot. Gard. Herb.); prairies, Lee's Summit, 9 May, 1897, *Bush 349* (Mo. Bot. Gard. Herb.); in woods, Courtney, 24 May, 1903, *Bush 1830* (Mo. Bot. Gard. Herb.); wooded hills, Courtney, 12 May, 1913, *Bush 6995* (Mo. Bot. Gard. Herb.); rocky woods, Dodson, 5 May, 1914, *Bush 7105* (Mo. Bot. Gard. Herb.); sandy hills and low prairies, Cass Co., May–June, 1885, and April, 1871, *Broadhead* (Mo. Bot. Gard. Herb.); prairies, Webb City, 4 May, 1902, *E. J. Palmer 314* (Mo. Bot. Gard. Herb.); high prairies, Carthage, 14 May, 1911, and 4 May, 1913, *E. J. Palmer 3373, 3383, 3942* (Mo. Bot. Gard. Herb.); high sandy prairies, Alba, 7 May, 1914, *E. J. Palmer 5518* (Mo. Bot. Gard. Herb.); Eagle Rock, 14 June, 1897, *Bush 182* (Mo. Bot. Gard. Herb.); McDonald Co., 22 April, 1891, *Bush* (Mo. Bot. Gard. Herb.).

Arkansas: Corning, May, 1884, *Letterman* (Berlin Herb., fragment in Gray Herb.); "Monark," 2 May, 1905, *Bush 2592* (Mo. Bot. Gard. Herb.).

Louisiana: west of Meriden, 15 April, 1901, *Canby, Sargent, Trelease & Bush 144* (Phil. Acad. Nat. Sci. Herb.); without definite locality, *Bradbury* (Phil. Acad. Nat. Sci. Herb.); "Upper Louisiana," *Nuttall* (Phil. Acad. Nat. Sci. Herb.), (?) TYPE; without definite locality, *Hale, ex Short Herb.* (Phil. Acad. Nat. Sci. Herb.).

Minnesota: Houston Co., May, 1912, *Freiberg* (Mo. Bot. Gard. Herb.); railroad banks, Perham, Ottertail Co., 20 July, 1912, *Chandonnet* (Mo. Bot. Gard. Herb.).

Iowa: Fayette Co., 3 June, 1894, *Fink 10* (U. S. Nat. Herb.); Iowa City, *Hitchcock* (Mo. Bot. Gard. Herb.); dry

hillsides, Lee Co., 19 May, 1914, *Rev. John Davis 2371, 3822* (Mo. Bot. Gard. Herb.); low ground on prairies, Armstrong, 14 June, 1883, and 5 June, 1898, *Cratty* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Burnside, 1 June, 1899, *Somes C. 3014* (U. S. Nat. Herb.); wet meadows, Decatur Co., 28 May, 1898, *Anderson* (Mo. Bot. Gard. Herb.); dry hills, near Council Bluffs, Nicollet's North-Western Expedition, 16 May, 1839, *Geyer 98* (Phil. Acad. Nat. Sci. Herb., Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); without definite locality, 9 June, 1875, *Arthur* (Mo. Bot. Gard. Herb.).

North Dakota: Conway, 2 July, 1896, *Brannon 193* (Mo. Bot. Gard. Herb.); dry prairie, Grand Forks, 12 June, 1896, *Brannon 232* (Mo. Bot. Gard. Herb.); on level prairie, Rogers, 10 June, 1912, *Bergman 1696* (Mo. Bot. Gard. Herb.); along bottom of open ravine, Adrian, 27 June, 1912, *Bergman 1808* (Mo. Bot. Gard. Herb.); wet prairie, Leeds, 11 June, 1899, *Lunell* (Gray Herb.).

South Dakota: prairies, "Oakwood," 23 May, 1902, *A. G. J.* (Mo. Bot. Gard. Herb.); Brookings, coll. of 1892, *Williams* (U. S. Nat. Herb.); Brookings, 20 June, 1893, *Thornber* (Mo. Bot. Gard. Herb.); Brookings, June, 1905, *White* (Mo. Bot. Gard. Herb.); Sioux Falls, 18 May, 1894, *Thornber* (Mo. Bot. Gard. Herb.); Fort Pierre to Yellowstone River, Raynolds' Expedition to the Headwaters of the Missouri and Yellowstone Rivers, July, 1859, *Hayden* (Mo. Bot. Gard. Herb.); grassy draws on plains, Washabaugh Co., 22 May, 1914, *Over 2088* (U. S. Nat. Herb.); Black Hills, near Fort Meade, 21 June, 1887, *Forwood 231* (U. S. Nat. Herb.); Custer, 16 July, 1892, *Rydberg 827* (Gray Herb.), in part; Hot Springs, 18 June, 1892, *Rydberg 828* (Gray Herb. and U. S. Nat. Herb.); Mayo, 18 June, 1914, *Over 1895* (U. S. Nat. Herb.).

Montana: Miles City, 26 May, 1902, *Blankenship* (Gray Herb.).

Nebraska: one hundred miles above Council Bluffs, 4 June, 1853, *Hayden* (Mo. Bot. Gard. Herb.); Mauvaises Terres, 12 July, 1853, *Hayden* (Mo. Bot. Gard. Herb.); Fremont, 3 June, 1893, *Schenck 6* (Mo. Bot. Gard. Herb.); prairies near Lincoln,

June, 1887, *Webber*, also 10 and 12 May, 1900, *Hedgcock* (Mo. Bot. Gard. Herb.); Minden, 11 June, 1907, *Hapeman* (Mo. Bot. Gard. Herb.); Big Blue and Little Blue Rivers to Big Platte River, June, 1849, *Fendler 71* (Gray Herb.); Republican Valley, Franklin Co., 15 May, 1893, *Laybourn* (Mo. Bot. Gard. Herb.); Hershey, 20 May, 1903, *Mell 46* (U. S. Nat. Herb.); along streams, Halsey, 27 May, 1903, *Mell & Knopff* (Mo. Bot. Gard. Herb.); Platte bottom, Kearney Co., 15 June, 1891, also Cheyenne Co., 3 Aug., 1891, *Rydberg 211* (U. S. Nat. Herb.); Nebraska (?), Stevens' Pacific Railway Expedition (U. S. Nat. Herb. 48724, 48726).

Colorado: near Evans and Greeley, colls. of June, 1907, 1908, and 1909, *E. L. Johnston 439, 441, 443, 445, 460, 546* (Mo. Bot. Gard. Herb.); New Windsor, Weld Co., 4 June, 1901, *Osterhout* (U. S. Nat. Herb. and Phil. Acad. Nat. Sci. Herb.); Fort Lupton, in Platte River bed, 19 May, 1 and 15 June, 1913, *E. L. Johnston 884, 872, 868* (U. S. Nat. Herb.); river flats, Fort Collins, alt. 1525 m., 17 May, 1895, *Crandall 281* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); cañon of the Cache-la-Poudre, 2 June, 1891, *Crandall* (U. S. Nat. Herb.); Denver, Lieut. Wheeler's Expedition, June, 1873, *Wolf 556* (U. S. Nat. Herb.); low meadows on Clear Creek, 23 May, 1870, *Greene 226* (Gray Herb.); near Breckenridge, 22 July, 1906, *Anderson* (Mo. Bot. Gard. Herb.); Horsetooth Gulch, 28 May, 1898, *Crandall 3070* (U. S. Nat. Herb.); wet meadow valley, 20 June, 1873, *Brandegee* (Mo. Bot. Gard. Herb.).

Kansas: Manhattan, coll. of 1884, *Kellerman 8* (Gray Herb.); Manhattan, 15 May, 1887, *Kellerman* (Mo. Bot. Gard. Herb.); Manhattan, 6 May, 1891, *Fritz* (U. S. Nat. Herb.); stony hills, Riley Co., 9 May, 1895, and coll. of 1896, *Norton 303* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Emporia, 29 April, 1890, *Tyler* (Mo. Bot. Gard. Herb.); Cowley, *White* (Mo. Bot. Gard. Herb.); dry prairies, near Osborne City, 14 May, 1894, *Shear 28* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.).

Oklahoma: Huntsville, Kingfisher Co., 29 April, 1896, *Blankenship* (Gray Herb., U. S. Nat. Herb., and Mo. Bot.

Gard. Herb.); Sapulpa, 29 and 30 April, 1895, *Bush 1249, 975* (Mo. Bot. Gard. Herb.); between Fort Cobb and Fort Arbuckle, *Palmer 461* (U. S. Nat. Herb.); without definite locality, 16 April, 1893, *Waugh 275* (Mo. Bot. Gard. Herb.); without locality, *Stevens 34, 50.2A, 120, 134, 146, 163, 179.6A, 210, 233, 286½, 301½, 420H, 469* (Geo. W. Stevens Herb.).

Texas: rich woods, Dallas, March, 1882, *Reverchon 556* (Mo. Bot. Gard. Herb.); on prairie, Dallas, 15 April, 1900, *Bush 606* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); rocky prairies, Fort Worth, 21 April, 1902, *Reverchon* (Mo. Bot. Gard. Herb.); hillsides, Polytechnic, 5 March, 1913, *Ruth 54* (Mo. Bot. Gard. Herb.); Limestone Co., March, 1878, *Joor* (U. S. Nat. Herb.); College Station, Brazos Co., *Ness 2083* (Mo. Bot. Gard. Herb.); sandy prairies, Terrell, 6 April, 1903, *Reverchon 3964* (Gray Herb. and Mo. Bot. Gard. Herb.); Round-top Mountain, Comanche Co., 9 May, 1900, *Eggert* (Mo. Bot. Gard. Herb.); Georgetown, March, 1890, *Bodin 53* (U. S. Nat. Herb); Gillespie Co., *ex Herb. Jermy* (Mo. Bot. Gard. Herb.); New Braunfels, April, 1851, *Lindheimer* (Mo. Bot. Gard. Herb.); in patches on rocky high plains, Upper Guadeloupe, coll. of March, 1846, *Lindheimer 445* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.).

67. **S. Willingii** Greenm. Ottawa Nat. **25**:117. 1911.

An herbaceous perennial, somewhat glaucous; stems erect, 2.5 to 3 dm. high, glabrous, striate, leafy; leaves oblong-lanceolate, 3 to 12 cm. long, .7 to 2 cm. broad, crenate-serrate to pinnately divided into oblong, entire or obtusely dentate lobes obtuse to rounded at the apex, in the early stages floccose-tomentulose along the midrib and lateral nerves beneath and on the margins of the petioles, later glabrate; inflorescence a terminal, rather dense, corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, calyculate, sparingly floccose-tomentulose, glabrate; bracts of the involucre about 21, linear-lanceolate, 6 to 7 mm. long, acute; ray-flowers about 12, rays yellow; disk-flowers numerous, 60 to 70; achenes glabrous.

Distribution: Manitoba to Alberta.

Specimens examined:

Manitoba: gravelly soil, Ninga, 1 June, 1908, *Hales 24* (Geol. Surv. Canada Herb.).

Alberta: near Olds, Aug., 1894, *Willing* (Geol. Surv. Canada Herb. 14843, 6063, fragment and photograph in Field Mus. Herb.), TYPE.

68. S. Smallii Britt. Mem. Torr. Bot. Club **4**:132. 1894; Britton & Brown, Ill. Fl. **3**:479, *fig. 4044*. 1898, and ed. 2, 546, *fig. 4630*. 1913; Heller, Cat. N. Am. Pl. 147. 1898, and ed. 2, 231. 1900; Britton, Manual 1028. 1901, and ed. 2, 1905; Small, Fl. Southeastern U. S. 1304. 1903, and ed. 2, 1913; Greenm. in Gray, Manual, ed. 7, 854. 1908.

S. Balsamitae Ell. Sketch **2**:330. 1824, not Muhl.

S. aureus var. *Balsamitae* Gray, Syn. Fl. N. Am. **1**[2]:391. 1884, and ed. 2. 1886, in part; Chapman, Fl. Southern U. S. 245. 1860, ed. 2, 1889, and ed. 3, 266. 1897.

S. aureus var. *angustifolius* Britt. Mem. Torr. Bot. Club **2**:39. 1890, not *S. angustifolius* Willd.

S. Earlei Small, Bull. Torr. Bot. Club **25**:147. 1898.

(?) *S. Memmingeri* Britt. Bull. Torr. Bot. Club **25**:147. 1898.

An herbaceous perennial; stems one to several, erect from a common base, 2 to 6 dm. high, conspicuously and permanently woolly tomentose at the base and in the leaf-axils; lower leaves long-petiolate, narrowly oblong-oblanceolate, 1.5 to 13 cm. long, 1 to 3 cm. broad, obtuse to rounded at the apex, crenate to serrate-dentate, narrowed at the base into the petiole; petioles 1.5 to 18 cm. long; stem-leaves petiolate and sublyrate to sessile and more or less pinnatisect; inflorescence a terminal many-headed corymbose cyme; heads usually very numerous, relatively small, 7 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre 13 to 21, linear-lanceolate, 5 to 6 mm. long, glabrous; ray-flowers 8 to 13, rays yellow; disk-flowers numerous; achenes usually but not always hispidulous along the angles.

Distribution: southern Pennsylvania to Florida.

Specimens examined:

Pennsylvania: Tullytown, Bucks Co., 15 May, 1896, *Crawford* (Phil. Acad. Nat. Sci. Herb.); Westtown, Chester Co., 22 June, 1895, *Crawford* (Phil. Acad. Nat. Sci. Herb.); near Mt. Hope, in red sandstone, Lancaster Co., 24 June, 1901, *Heller* (Mo. Bot. Gard. Herb.).

Maryland: Baldfriar, Cecil Co., 4 July, 1907, *Bartram* (Phil. Acad. Nat. Sci. Herb.); Norbeck, 25 June, 1895, *Mearns* (U. S. Nat. Herb.); between Garrett Park and Kensington, 8 June, 1907, *Steele* (U. S. Nat. Herb.); field above Cabin John, 7 June, 1908, *Steele* (U. S. Nat. Herb.); dry slopes, Chevy Chase Lake, 30 May, 1911, *Standley 5983* (U. S. Nat. Herb.).

District of Columbia: vicinity of Washington, 10 June, 1877, and 27 May, 1878, *Ward* (U. S. Nat. Herb. 131112 in part, and 131111); Queen's Chapel Road, 12 June, 1888, *Burgess* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Garrett Park, June, 1894, and in open thickets, Brookland, 6 June, 1895, *Holm* (Mo. Bot. Gard. Herb.); Rock Creek Park, 26 May, 1895, *Pollard 285* (U. S. Nat. Herb.); vicinity of Washington, 25 May, 1896, *Steele* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); wooded side-hill of Piney Branch, Rock Creek Park, 27 May, 1899, *Maxon 140* (U. S. Nat. Herb.); Chevy Chase, 16 May, 1905, *House 721* (Mo. Bot. Gard. Herb.); Tenallytown, 14 June, 1871, *F. Blanchard* (Mo. Bot. Gard. Herb.).

Virginia: Fairfax Co., 7 June, 1902, *G. S. Miller* (U. S. Nat. Herb.); West End, Fairfax Co., 30 June, 1907, *Steele* (U. S. Nat. Herb.); dry woods, Falls Church, 30 May, 1912, *Ruth 164* (U. S. Nat. Herb.); open woods, Bluemont, Loudon Co., 31 May, 1915, *Standley 11621* (U. S. Nat. Herb.); dry fields, Hampton, 19 May, 1903, *G. S. Miller* (U. S. Nat. Herb.); Richmond, *de Chalmont* (U. S. Nat. Herb.); near Suffolk, Nansemond Co., 19 May, 1898, *Kearney 1271* (U. S. Nat. Herb.); near Branchville, Southampton Co., 12 June, 1893, *Heller 958* (Phil. Acad. Nat. Sci. Herb. and Mo. Bot. Gard. Herb.); in old fields, vicinity of Belfield, 21 May, 1904, *Meyncke* (U. S. Nat. Herb.); Appomattox, *Rumer* (U. S. Nat. Herb.); pine

woods, Bedford Co., *A. H. Curtiss* (Gray Herb. and Mo. Bot. Gard. Herb.); Peaks of Otter, 6 June, 1890, *Brown, Hogg, Vail, Timmerman & Britton* (U. S. Nat. Herb. and Greene Herb.); between Fall Creek and Danville, 3 June, 1891, *Small & Heller 234* (U. S. Nat. Herb.); vicinity of Marion, Smyth Co., alt. 640 m., 6 June, 1892, *N. L. and E. Britton & Vail* (Phil. Acad. Nat. Sci. Herb.); Hutton's Branch, East Marion, alt. 760 m., 6 June, 1892, *Small* (Mo. Bot. Gard. Herb.); along Comer Creek, 15 June, 1892, alt. 915 m., *Small* (U. S. Nat. Herb.).

North Carolina: Weldon, *Williamson* (C. S. Williamson Herb.); vicinity of Heilig's Mill, Rowan Co., 4–9 June, 1891, *Small & Heller 490* (Mo. Bot. Gard. Herb.); in woods, near Faith, 27 May, 1891, *Heller 10263* (Mo. Bot. Gard. Herb.); Statesville, *Hyams* (Mo. Bot. Gard. Herb.); near Hickory, alt. 550 m., 23 June, 1893, *Heller* (Phil. Acad. Nat. Sci. Herb.); east of Blowing Rock, Caldwell Co., 24 June, 1893, alt. 1065 m., *Heller* (Phil. Acad. Nat. Sci. Herb.); dry open woods and clearings, Biltmore, 14 June, 1900, *Mohr* (U. S. Nat. Herb.); vicinity of Asheville, May, 1888, *McCarthy* (U. S. Nat. Herb.); dry woods and waste places, Biltmore, 20 May, 1896, *Biltmore Herb. 1233* (Mo. Bot. Gard. Herb.); old fields, Biltmore, 11 June, 1897, *Biltmore Herb. 1233b* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); "Half Way," Black Mountain, 27 June, 1902, *Harshberger 79* (U. S. Nat. Herb. and Phil. Acad. Nat. Sci. Herb.); Tryon, Polk Co., 22 May, 1899, *Churchill* (Gray Herb.); foot of mountain, Tryon, 22 May, 1897, *Townsend* (U. S. Nat. Herb.); Sunburst, Haywood Co., alt. 975 m., 19 June, 1910, *House 4339* (U. S. Nat. Herb.); without definite locality, June, 1879, *Gray, Sargent, Redfield & Canby* (Gray Herb.); on mountain bluff, *Gray & Carey* (Gray Herb.), small form.

South Carolina: Table Rock, Pickens Co., *Buckley* (Gray Herb.); dry woods and fields, Fort Hill, Oconee Co., 30 April, 1906, *House 1994* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); without locality, May, 1867, *Ravanel* (Gray Herb.).

Georgia: Gainesville, 10 May, 1879, *Trelease* (Mo. Bot. Gard. Herb.); dry woods on highest summit of Pigeon Moun-

tains, Walker Co., alt. 710 m., 1 Aug., 1900, *Harper 338* (U. S. Nat. Herb.); Lookout Mountain, July, 1898, *Ruth 673* (U. S. Nat. Herb.) and *704* (Mo. Bot. Gard. Herb.); Lookout Mountain, 25 May, 1901, *Trelease* (Mo. Bot. Gard. Herb.); Thompson's Mills and vicinity, Gwinnett Co., 26 April, 1908, *Allard 267, 268* (U. S. Nat. Herb.); Stone Mountain, 13 May, 1901, *A. H. Curtiss 6780* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Stone Mountain, 23 May, 1897, and 17 May, 1899, *Eggert* (Mo. Bot. Gard. Herb.); rocky places, Covesprings, 15 May, 1881, *Mohr* (U. S. Nat. Herb.); Tallapoosa, April and May, 1900, *Way 30* (U. S. Nat. Herb.); Lagrange, 16 May, 1905, *Tracy 8944* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); without definite locality, *Boykin* (Phil. Acad. Nat. Sci. Herb.).

Alabama: Wedowee, Randolph Co., 28 May, 1874, *Mohr* (U. S. Nat. Herb.); Auburn, Lee Co., colls. of 1897 and 1898, *Earle & Baker* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); dry, open places, Auburn, 10 June, 1901, *Earle* (Gray Herb.); Cullman, May, 1886, and June, 1895, *Mohr* (U. S. Nat. Herb.); without definite locality, June, 1889, *Miss Emily Mohr* (U. S. Nat. Herb. 782485).

Florida: without definite locality, *Chapman* (Gray Herb. and Mo. Bot. Gard. Herb.).

Tennessee: dry ground, Knoxville, May, 1898, *Ruth 672* (U. S. Nat. Herb.); dry sterile grounds, Knoxville, June, 1898, *Ruth 703* (Mo. Bot. Gard. Herb.).

This species, *S. Smallii,* and the following, *S. pauperculus,* are, as a rule, easily distinguished by the taller stems, longer leaves, more numerous and somewhat smaller heads of the former; but in southeastern Pennsylvania and in Maryland occasional forms occur, for example, Crawford's specimen from Tullytown, 15 May, 1896, and Small's specimen from Mt. Hope, 24 June, 1901, which are somewhat intermediate. These two specimens seem to the writer to possess rather more the characters of *S. Smallii* than of *S. pauperculus.* Moreover, Crawford's specimen from Westtown, Pa., 22 June, 1895, is a perfect match for Heller's specimen, No. 10263,

from North Carolina, as well as certain other collections from the southern states. The range of *S. Smallii* may be said therefore to extend to southern Pennsylvania.

69. S. pauperculus Michx.[1] Fl. Bor. Am. **2**:120. 1803; Pursh, Fl. Am. Sept. **2**:529. 1814, and ed. 2, 1816; DC. Prodr. **6**:432. 1837; Britton & Brown, Ill. Fl. **3**:545, *fig. 4629*. 1913.

S. Balsamitae Muhl. ex. Willd. Sp. Pl. **3**:1998. 1804; Pursh, Fl. Am. Sept. **2**:530. 1814, and ed. 2, 1816, excl. synonymy; Beck, Bot. Northern and Middle States 200. 1833, excl. synonym; Darlington, Fl. Cest. 497. 1837; Heller, Cat. N. Am. Pl. 146. 1898, and ed. 2, 229. 1900; Britton & Brown, Ill. Fl. **3**:479, *fig. 4043*. 1898; Britton, Manual 1027. 1901, and ed. 2, 1905, in major part; Greenm. in Rhodora **3**:5. 1901; Monogr. Senecio, I. Teil, 23. 1901, and in Engl. Bot. Jahrb. **32**:19. 1902; Porter, Fl. Penn. 339. 1903; Keller & Brown, Handb. Fl. Phil. and Vicinity 343. 1905; Greenm. in Gray, Manual, ed. 7, 854. 1908; Small, Fl. Lancaster County 310. 1913.

S. aureus var. *Balsamitae* Torr. & Gray, Fl. N. Am. **2**:442. 1843, in part; Torr. Nat. Hist. N. Y., pt. 2, Botany **1**:402. 1843; Britton, Cat. Pl. N. J. 54. 1881; *ibid.* 150. 1890; Gray, Syn. Fl. N. Am. **1**[2]:391. 1884, and ed. 2, 1886, in part; Macoun, Cat. Canadian Pl. 265. 1884, in major part.

S. Balsamitae var. *praelongus* Greenm. Rhodora **3**:6. 1901; Graves et al. Conn. Geol. and Nat. Hist. Surv. Bull. No. 14, p. 404. 1910.

An herbaceous perennial, somewhat tomentulose, particularly at the base of the stem and in the leaf-axils, to glabrous; stems erect or nearly so, one to several from a common base, 1 to 4 dm. high; lower leaves petiolate, narrowly oblong oblanceolate, including the petiole 2 to 18 cm. long, .5 to 2 cm. broad, rounded to obtuse at the apex, crenate to serrate-dentate, gradually narrowed at the base; stem-leaves petiolate and sublyrate to sessile and pinnatisect; inflorescence a terminal few to several-headed corymbose cyme, occasionally reduced to a single head; heads 5 to 10 mm. high, radiate; in-

[1]The name *pauperculus* is here maintained for this species instead of *Balsamitae* largely on the statement of Dr. Otto Kuntze, Rev. Gen. Pl. 1: CXXXIV, CXXXV. 1891.

volucre campanulate, calyculate; bracts of the involucre (13–) 21, linear-lanceolate, 3 to 6 mm. long, usually glabrous; ray-flowers 8 to 13, rays yellow; disk-flowers numerous; achenes glabrous or hirtellous along the angles.

Distribution: Labrador to Minnesota, south to Virginia and Missouri.

Specimens examined:

Labrador: hills near lighthouse, Forteau, 23 Aug., 1894, *Waghorne 29* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); boggy spots, and in wet moss by spring, Blanc Sablon, Strait of Belle Isle, 1 Aug., 1910, *Fernald & Wiegand 4185, 4186* (Gray Herb.); wet limestone and calcareous sandstone terraces, Blanc Sablon, 6 Aug., 1910, *Fernald & Wiegand 4178* (Gray Herb.).

Newfoundland: damp limestone barrens, near sea-level, Pointe Riche, 4 Aug., 1910, *Fernald & Wiegand 4176* (Gray Herb.); dry rocky limestone barrens, near sea-level, Ingornachoix Bay, 4 Aug., 1910, *Fernald & Wiegand 4177* (Gray Herb.); barrens at the base of serpentine tablelands, Bonne Bay, 27 Aug., 1910, *Fernald & Wiegand 4179* (Gray Herb.); crests of sea cliffs, Western Head, New Worlds Island, Notre Dame Bay, 20 July, 1911, *Fernald & Wiegand 6407* (Gray Herb.); boggy places on hill, southwest of Tilt Cove, Notre Dame Bay, 25 Aug., 1911, *Fernald & Wiegand 6412* (Gray Herb.); Fogo Island, 27 July, 1903, *Sornborger* (Gray Herb.); ledges and talus, north bank of river below Grand Falls, 3 July, 1911, *Fernald & Wiegand 6402* (Gray Herb.); open bogs among the hills, Grand Falls, 23 July, 1911, *Fernald & Wiegand 6411* (Gray Herb.); bog, Grand Falls, 5 July, 1911, *Williamson* (C. S. Williamson Herb.); shingly beach, north bank of river, below Grand Falls, 22 July, 1911, *Fernald & Wiegand 6406* (Gray Herb.); gravelly river bank, Glenwood, 12 and 13 July, 1911, *Fernald & Wiegand 6403, 6404* (Gray Herb.); Tilton Harbor to Barred Island, 31 July, 1903, *Sornborger* (Gray Herb.); Barred Island, 13 Aug., 1903, *Sornborger* (Gray Herb.); swamp, foot of Helmet, Holyrood, 22 Aug., 1894, *Robinson & Schrenk* (Gray Herb.); near confluence

of Exploits River and Badger Brook, 13 Aug., 1894, *Robinson & Schrenk* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); sandy clearing, Mary Anne Brook, 14 July, 1911, *Fernald & Wiegand 6410* (Gray Herb.); dry bog, Millertown Junction, 7 July, 1911, *Fernald & Wiegand 6408* (Gray Herb.); damp talus slopes of the marble region between Mt. Musgrave and Humber Mouth (Bay of Islands Station), 18 July, 1910, *Fernald & Wiegand 4183* (Gray Herb.); gravelly beach, Middle Birchy Pond, 11 July, 1910, *Fernald & Wiegand 4182* (Gray Herb.); open tundra along Junction Brook, 12 and 13 July, 1911, *Fernald & Wiegand 6409* (Gray Herb.); boggy places on the hill back of Summerside, 11 July, 1910, *Fernald & Wiegand 4181* (Gray Herb.); open peat bog among Silurian hills, back of Birchy Cove (Curling), 8 July, 1910, *Fernald & Wiegand 4180* (Gray Herb.); serpentine and magnesian limestone barrens, northeastern bases and slopes of Blomidon (Blow-me-down) Mountains, 24 July, 1910, *Fernald & Wiegand 4184* (Gray Herb.); barrens at the base of serpentine table-lands, Bonne Bay, 27 Aug., 1910, *Fernald & Wiegand 4187* (Gray Herb.); fields, Coal River, 14 July, 1896, *Waghorne 15* (Gray Herb.), and 16 July, 1896, *Waghorne 12* (Mo. Bot. Gard. Herb.); sandy shore, Grand Lake, Bay of Islands, 11 Aug., 1896, *Waghorne 45* (Gray Herb.); sea-bank, near Chimney Cove, Bay of Islands, *Waghorne 8* (Gray Herb.); Bay of Islands, 24 June, 1895, *Waghorne 23* (Mo. Bot. Gard. Herb.), and 18 July, 1895, *Waghorne* (U. S. Nat. Herb.); open bog, Bay of Islands, 23 July, 1908, *Eames & Godfrey 8131* (Gray Herb.).

Quebec: rocky shores, River de Brig, Anticosti, 10 July, 1883, *Macoun* (U. S. Nat. Herb.); ravine, Mt. Albert, Gaspé Co., 26 July, 1881, *ex Herb. J. A. Allen* (U. S. Nat. Herb.); crevices and talus of serpentine, gulch north of Lac au Diable, Mt. Albert, Gaspé Co., alt. 750–950 m., 25 July, 1906, *Collins & Fernald 752* (Gray Herb.); cold wet rocks, head of au Diable, alt. 950 m., 8–15 Aug., 1905, *Collins & Fernald* (Gray Herb.); calcareous marl, Trout Pond, mouth of Grand River, Gaspé Co., 11–15 Aug., 1904, *Collins, Fernald & Pease* (Gray

Herb.); banks of Grand River, 20 June–10 July, 1903, *Richards* (Gray Herb.); banks of Grand River, Gaspé Co., 30 June–3 July, 1904, *Fernald* (Gray Herb.); gravelly beaches and flats, also wet alluvial shores, between Baldé and Baie des Chaleurs, Bonaventure River, 5, 6 and 7 Aug., 1904, *Collins, Fernald & Pease* (Gray Herb.); Gatineau River, 6 Sept., 1894, *Macoun* (Mo. Bot. Gard. Herb.); gravel beaches near the mouth of Dartmouth River, 26 and 27 Aug., 1904, *Collins, Fernald & Pease* (Gray Herb.), form with proliferous heads, also with both radiate and discoid heads.

Ontario: Plevna, 20 June, 1902, *Fowler* (Gray Herb.); sand ridges north of Sarnia, Lambton Co., 13 June, 1895, *Dodge 109* (U. S. Nat. Herb.); region of Lake Superior, *Macoun 52* (Mo. Bot. Gard. Herb.).

Maine: sunny alluvium, Fort Kent, 6 July, 1904, *Fernald* (Gray Herb.); rocky ledges, Fort Kent, 19 July, 1908, *Mackenzie 3600* (Mo. Bot. Gard. Herb.); rocky river-flat, Fort Kent, 10 July, 1908, *Mackenzie 3418* (Mo. Bot. Gard. Herb.); gravelly shores, Fort Fairfield, 5 July, 1893, *Fernald 71* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Pamedumcook Lake, 10 Aug., 1881, *Chickering* (Gray Herb. and U. S. Nat. Herb.); rocks in river, Orono, 1 July, 1890, *Fernald* (Gray Herb.).

New Hampshire: Sumner's Falls, 27 June, 1898, *Eggleston* (Mo. Bot. Gard. Herb.), and 25 June, 1902, *Eggleston 2804* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.).

Vermont: Colchester, coll. of 1842, *Oakes* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Winooski High Bridge, 14 June, 1881, *E. & C. E. Faxon* (Gray Herb.); Barnet, 20 June, 1884, *F. Blanchard* (Mo. Bot. Gard. Herb.); Manchester, 27 June, 1898, *Day 210* (Gray Herb. and U. S. Nat. Herb.); Bellows Falls, coll. of 1901, *W. H. Blanchard* (Gray Herb.); Putney, 8 June, 1902, *W. H. Blanchard* (Gray Herb.); without definite locality, *Robbins* (Phil. Acad. Nat. Sci. Herb.).

Massachusetts: Danvers, without date, *Oakes* (Phil. Acad. Nat. Sci. Herb.); without definite locality, *Oakes* (Gray

Herb.); rocky woods near summit of Blue Hill, Milton, *Rich* (Gray Herb.).

New York: Watertown, Jefferson Co., coll. of 1834, *Torr. & Gray, Fl. N. Am.* (Gray Herb.); rocky banks of Blue River, Watertown, 3 July, 1857, *ex Herb. Wm. Boott* (Gray Herb.); Dexter, *ex Herb. Geo. Vasey* (Gray Herb.); Oneida Co., coll. of 1864, *Paine* (Gray Herb.); sandy bog, near Syracuse, 22 June, 1882, *Sheldon* (Phil. Acad. Nat. Sci. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); tamarack swamp, near Syracuse, 28 May, 1902, *House* (U. S. Nat. Herb.).

New Jersey: low meadows, Newfoundland, Morris Co., 14 June, 1908, *Mackenzie 3119* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); dry woods, Chatham, 30 May, 1903, *Mackenzie 182* (Mo. Bot. Gard. Herb.); dry fields, Murray Hill, Union Co., 30 May, 1906, *Mackenzie 2044* (Mo. Bot. Gard. Herb.); Somerset Co., *Perry* (Mo. Bot. Gard. Herb.).

Pennsylvania: Laanna, Pike Co., 9 June, 1906, *Long* (Phil. Acad. Nat. Sci. Herb.); Allentown, 18 June, 1899, *Dowell* (U. S. Nat. Herb.); Manganese Park, southeast of Allentown, 8 June, 1908, near Mountainville, 13 June, 1908, and 13 June, 1914, also near Lanark, 24 May, 1908, *Pretz 1232, 1253, 6636, 1197* (Phil. Acad. Nat. Sci. Herb.); Nockamixon, Bucks Co., June, 1892, *Crawford* (Phil. Acad. Nat. Sci. Herb.); Rockhill, 19 June, 1892, *MacElwee* (Phil. Acad. Nat. Sci. Herb.); Perkasie, June, 1881, *Fretz* (Phil. Acad. Nat. Sci. Herb.); Tunnel Hill near Perkasie, 31 May, 1903, *MacElwee* (Phil. Acad. Nat. Sci. Herb.); Perkasie, 30 May, 1906, *Brown* (Phil. Acad. Nat. Sci. Herb.); near Sellersville, 7 June, 1893, *Porter* (Phil. Acad. Nat. Sci. Herb.); along Perkiomen Creek, near Sellersville, 2 June, 1899, *MacElwee 408* (Phil. Acad. Nat. Sci. Herb.); Argus, 6 June, 1898, *Fretz* (Phil. Acad. Nat. Sci. Herb.); Aquetong, 30 May, 1910, *Keller* (Phil. Acad. Nat. Sci. Herb.); Sumneytown, 30 May, 1903, *Jahn,* and 30 May, 1905, *Keller* (Phil. Acad. Nat. Sci. Herb.); Sumneytown, 30 May, 1903, *Williamson* (C. S. Williamson Herb.); dry fields along Wissahickon Creek, Penllyn, 12 June, 1909, *Long* (Phil. Acad. Nat. Sci. Herb.); between Hillside and Ardsley, 12 Oct., 1907, *Long*

(Phil. Acad. Nat. Sci. Herb.); near Noble, 13 June, 1912, *Long 7085* (Phil. Acad. Nat. Sci. Herb.); Layfayette, 2 June, 1895, *Keller, Jahn,* also *Uselma C. Smith 816* (Phil. Acad. Nat. Sci. Herb.); Layfayette, 5 June, 1897, *Jahn* (Phil. Acad. Nat. Sci. Herb.); serpentine barrens, Newtown, Delaware Co., 25 June, 1901, *Benj. H. Smith* (Phil. Acad. Nat. Sci. Herb.); serpentine barrens, near Newtown Square, 12 June, 1899, *MacElwee 491, 505* (Phil. Acad. Nat. Sci. Herb.); Williamson, 4 June, 1891, *Crawford,* 28 July, 1899, *MacElwee 999,* and 11 June, 1911, *Pennell 2764, 3641* (Phil. Acad. Nat. Sci. Herb.); Media, 30 May, 1896, *Githens* (Phil. Acad. Nat. Sci. Herb.); Elwyn, 8 June, 1890, *Brinton,* and 9 June, 1890, *ex Herb. Beringer* (Phil. Acad. Nat. Sci. Herb.); Wawa, 5 July, 1908, *Pennell 15,* and 9 June, 1896, *Bartram* (Phil. Acad. Nat. Sci. Herb.); Chester Heights, 23 June, 1907, *Pennell* (Phil. Acad. Nat. Sci. Herb.); Mineral Hill, 9 June, 1911, and 6 Sept., 1908, *Pennell 2719, 610* (Phil. Acad. Nat. Sci. Herb.); Fawkes Run, 30 May, 1909, and 10 June, 1911, *Pennell 1365, 2742* (Phil. Acad. Nat. Sci. Herb.); Phoenixville, Chester Co., coll. of 1865, *Martindale* (Phil. Acad. Nat. Sci. Herb.); Sugartown Barrens, 22 July, 1908, *Pennell 293,* and serpentine ridge, northwest of Sugartown, 30 May, 1909, *Pennell 1379* (Phil. Acad. Nat. Sci. Herb.); serpentine ridge, Willistown, 28 May, 1904, *Painter 673* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Willistown barrens, 24 May, 1908, *Williamson* (Phil. Acad. Nat. Sci. Herb.); serpentine ridge, Chester Co., June, 1882, *Windle* (U. S. Nat. Herb.); Westtown, 22 June, 1895, *Crawford* (Phil. Acad. Nat. Sci. Herb.); Fern Hill, 7 June, 1909, *Long* (Phil. Acad. Nat. Sci. Herb.); West Chester, coll. of 1828, *Wm. Darlington* (Phil. Acad. Nat. Sci. Herb.); West Chester, without date, *David Townsend,* and 29 May, 1909, *Pennell 1344* (Phil. Acad. Nat. Sci. Herb.); Sconnelltown, 29 July, 1908, *Pennell 343* (Phil. Acad. Nat. Sci. Herb.); Nottingham Barrens, 22 May, 1912, *Pennell & Long 3715, 7538* (Phil. Acad. Nat. Sci. Herb.); Cedar Barrens, Chester Co., 30 May, 1909, and 10 June, 1911, *Pennell 1395, 2760* (Phil. Acad. Nat. Sci. Herb.); high above Muddy Run, 5 July, 1904, *Crawford* (Phil.

Acad. Nat. Sci. Herb.); Pequea, June, 1893, *Eby* (Mo. Bot. Gard. Herb.); near Mt. Hope, 5 June, 1900, *Heller* (Gray Herb. and U. S. Nat. Herb.); Conewago, 28 May, 1889, *Heller* (Gray Herb.); in wet meadow, Rock Hill, 31 May, 1903, *MacElwee* (Phil. Acad. Nat. Sci. Herb.); Rawlinsville, coll. of 1884, *ex Herb. Galen* (Gray Herb.); Fulton, June, 1906, *Carter* (Phil. Acad. Nat. Sci. Herb.); near Pleasant Grove, in serpentine barrens, 5 June, 1901, *Heller* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); dry ground, near Round Top, Gettysburg, Adams Co., 24 June, 1894, *MacElwee* (Phil. Acad. Nat. Sci. Herb.); York Co., 3 June, 1895, *Glatfelter* (Mo. Bot. Gard. Herb.); Ohiopyle, Fayette Co., 3–8 June, 1905, *Brown, Crawford & Van Pelt* (Phil. Acad. Nat. Sci. Herb.).

Delaware: dry serpentine barrens, near Centerville, 15 June, 1866, and 10 July, 1868, *Commons* (Phil. Acad. Nat. Sci. Herb.); on serpentine, south of Mount Cuba, 18 June, 1914, *Pennell 1510* (Phil. Acad. Nat. Sci. Herb.); near Cooch's Mill, 29 May, 1896, *Commons* (Phil. Acad. Nat. Sci. Herb. 543180), in part.

Maryland: Rockville, 30 May, 1905, *Painter 1366* (Mo. Bot. Gard. Herb.); Brooklyn, 30 May, 1899, *Thurston* (U. S. Nat. Herb.); Laurel, 23 May, 1897, *Knowlton* (U. S. Nat. Herb.); College Park, 28 May, 1900, *Stewart* (Mo. Bot. Gard. Herb.); Mountain Lake Park, Garrett Co., *Shreve 560* (U. S. Nat. Herb.).

Virginia: on rocks in moss, Great Falls, June, 1903, *Painter 357* (U. S. Nat. Herb.).

Michigan: "L. Superior, Pic to Sault", *Loring* (Gray Herb.); Macinaw City, 12 Aug., 1890, *Wheeler* (Gray Herb.); Thunder Bay Island, Alpena Co., 18 July, 1895, *Wheeler* (Gray Herb.); North Point, Alpena Co., 3 July, 1895, *Wheeler* (U. S. Nat. Herb.); dry woods near Hillman, Montmorency Co., 7 July, 1895, *Wheeler* (U. S. Nat. Herb.); Clarkston, 30 June, 1888, *Hicks* (U. S. Nat. Herb.); marl beds on Parkdale Farm, colls. of 1912, 1913, and 1914, *Farwell 2652, 2653, 3491, 3659, 3660* (Mo. Bot. Gard. Herb.).

Ohio: Marblehead Peninsula, 20 May, 1895, *Moseley* (U. S. Nat. Herb.).

Indiana: Mineral Springs, 14 June, 1911, *Nieuwland 2657* (Mo. Bot. Gard. Herb.); moist sands and swales, Pine, 12 June, 1897, *Umbach* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); sandy soil, Edgmoor, Lake Co., 13 June, 1891, *Moffatt 451* (Field Mus. Herb.); prairie, Roby, 18 June, 1910, *Lansing 2784* (U. S. Nat. Herb.).

Minnesota: Center City, June, 1892, *Taylor* (U. S. Nat. Herb.); damp places near Minneapolis, June, 1892, *Burglehaus* (Mo. Bot. Gard. Herb.); without definite locality, July, 1899, *Woods* (U. S. Nat. Herb.); without locality, June, 1849, *Dr. Sykes* (Mo. Bot. Gard. Herb.).

Wisconsin: "N. W. America", *Long* (Mo. Bot. Gard. Herb.).

Illinois: in moist sandy soil near Lake Michigan, Beach, 16 June, 1907, *Greenman 1987, 2015* (Mo. Bot. Gard. Herb.); rich meadow, Beverly Hills, 6 June, 1903, *Chase 2066* (U. S. Nat. Herb.); Morgan Park, 27 May, 1907, *Dixon & Gage 710* (U. S. Nat. Herb.).

Missouri: near Mark Twain's Cave, Ralls Co., 5 May, 1914, *Rev. John Davis 2333* (Mo. Bot. Gard. Herb.).

Var. **firmifolius** (Greenm.) comb. nov.

S. Balsamitae var. *firmifolius* Greenm. Rhodora 7:244. 1905.

Stems .5 to 2.5 dm. high, simple or branched, more or less tufted; lower leaves mostly short-petiolate, subrotund, oblong-elliptic to oblong-oblanceolate, .5 to 4 cm. long, 5 to 20 mm. broad, crenate-dentate to sublyrately pinnatifid, at first as well as the stem somewhat tomentulose, later more or less glabrate and thickish or firm in texture; upper stem-leaves sessile and pinnatisect to linear and bracteiform.

Distribution: in limestone detritus, crest of Les Murailles, Percé, Gaspé Co., 17 Aug., 1904, *Collins, Fernald & Pease* (Gray Herb.), TYPE; limestone detritus, Mont Rouge, Percé, Gaspé Co., 23 July, 1905, *Collins & Fernald* (Gray Herb.); limestone detritus, Cap Barré, Percé, Gaspé Co., 23 July,

1905, *Collins & Fernald 147* (Gray Herb. and U. S. Nat. Herb.); limestone shingle near summit of Baldé, Bonaventure Co., 5, 6, and 8 Aug., 1904, *Collins, Fernald & Pease* (Gray Herb.); wet red sandstone bluffs and steep slopes, between Baldé and the Baie des Chaleurs, Bonaventure River, 5, 6, and 8 Aug., 1904, *Collins, Fernald & Pease* (Gray Herb.); ledgy banks of the Restigouche River, Metapedia, 19 July, 1904, *Collins & Fernald* (Gray Herb.). The last three specimens cited are transitional forms between the variety and the species.

70. S. flavovirens Rydb. Bull. Torr. Bot. Club **27**:181, *pl. 5, fig. 4.* 1900, mainly; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

S. fulgens Rydb. Bull. Torr. Bot. Club **27**:177, *pl. 6, fig. 13.* 1900, not. Nichols.

S. Rydbergii Nels. in Coulter & Nelson, Manual Cent. Rocky Mountains 582. 1909.

S. Balsamitae Rydb. Mem. N. Y. Bot. Gard. **1**:446. 1900, mainly, not Muhl.; Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains 583. 1909, not Muhl.

S. flavulus Rydb. Fl. Colo. 397. 1906, in part, not Greene.

An herbaceous perennial, pale or yellowish green in the dried state, glabrous or slightly white-tomentulose along the margins of the petioles near their base and in the axils of the leaves; stems erect, 2 to 5 dm. high; lower leaves petiolate, oblanceolate to oval, 1 to 6 cm. long, .5 to 2 cm. broad, gradually narrowed into the petiole to abruptly constricted at the base, crenate to coarsely and unequally dentate, obtuse or rounded at the apex, glabrous on both surfaces; stem-leaves petiolate and more or less lyrate to sessile and pinnatisect; inflorescence a terminal few-headed corymbose cyme; heads 7 to 9 mm. high, radiate; involucre campanulate, calyculate; bracts of the involucre 13 to 21, linear-lanceolate, 5 to 7 mm. long, pale or yellowish green and glabrous except at the brownish penicillate tip, becoming thickish in texture; ray-flowers 10 to 12, rays bright yellow; disk-flowers numerous; achenes glabrous or slightly hirtellous along the angles.

Distribution: British Columbia, south to Colorado and Idaho.

Specimens examined:

British Columbia: Field, 12 July, 1904, *Farr* (Univ. Penn. Herb.); Ottertail Drive, near Field, 15 July, 1905, *Farr 817, 818* (Univ. Penn. Herb.); border of an alkali marsh, Similkameen River, 10 June, 1905, *Macoun 69356* (Gray Herb.); Lower Fraser River, N. Lat. 49°, Oregon Boundary Commission, coll. of 1859, *Dr. Lyall* (Gray Herb.).

Montana: Big Fork, Aug., 1908, *Mrs. Joseph Clemens* (Field Mus. Herb. and Mo. Bot. Gard. Herb.).

Yellowstone National Park: Mammoth Hot Springs, 5 July, 1899, *Blankenship* (Gray Herb.); about willow clumps on river bottom, Snake River, 12 Aug., 1899, *A. & E. Nelson 6402* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Fitzgerald's Ranch, near Gardiner Mountain, 3 July, 1902, *Mearns 1493* (U. S. Nat. Herb. and Field Mus. Herb.).

Wyoming: low ground, Adam's Ranch, Jackson's Hole, 15 July, 1901, *Merrill & Wilcox 967* (U. S. Nat. Herb.); sandy soil, Blue Lakes on Wind River, 6 July, 1881–82, *Forwood* (U. S. Nat. Herb.); Wind River, Aug., 1894, *A. Nelson 760* (Gray Herb. and U. S. Nat. Herb.); Horse Creek, coll. of 1893, *A. Nelson 100* (U. S. Nat. Herb.); Green River, 26 July, 1894, *A. Nelson 1036* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Dale Creek, near Sherman, 29 July, 1884, *Letterman* (Mo. Bot. Gard. Herb.); Evanston, 10 July, 1897, *Williams* (U. S. Nat. Herb.); La Barge, Uinta Co., 18 July, 1894, *Stevenson 201* (U. S. Nat. Herb.); Myer's ranch, Bear River, south of Evanston, alt. 2285–2440 m., 26 July, 1902, *Pammel & Blackwood 4044* (Mo. Bot. Gard. Herb.).

Colorado: N. Lat. 39–41°, coll. of 1862, *Hall & Harbour 332*, in part (Phil. Acad. Nat. Sci. Herb. and Mo. Bot. Gard. Herb.), and *115*, in part (Gray Herb.); Colorado Springs, May, 1878, *Jones* (U. S. Nat. Herb. 223024, in part).

Idaho: open grassy stream lands, Mackay, Custer Co., 1 Aug., 1911, *Nelson & Macbride 1500* (Mo. Bot. Gard. Herb.); Arco, 19 June, 1893, *E. Palmer 193* (U. S. Nat. Herb.).

Var. **thomsoniensis** (Greenm.) comb. nov.

S. Balsamitae var. *thomsoniensis* Greenm. Ottawa Nat. **25**:116. 1911.

S. Balsamitae Greenm. Ottawa Nat. **25**:116. 1911, not Muhl.

Stems 1.2 to 4.5 dm. high, at first floccose-tomentulose later more or less glabrate; lower leaves oblong-oblanceolate, the blade 1 to 7 cm. long, 5 to 12 mm. broad, rounded or obtuse at the apex, crenate to serrate, gradually narrowed at the base into the petiole, at first tomentulose, particularly on the under surface, later more or less glabrate; inflorescence and base of the involucre often slightly tomentulose.

Distribution: Alaska to British Columbia and Montana.

Specimens examined:

Alaska: on gravel flood-plain of the Kuskokwim River, 19 July, 1902, *Brooks & Prindle* (U. S. Nat. Herb.).

British Columbia: Bonaparte River, 18 June, 1889, *Macoun* (U. S. Nat. Herb. 219791, in part); South Thompson River at Kamloops, 10 July, 1906, *E. Wilson 686, 672* (Mo. Bot. Gard. Herb. and Geol. Surv. Canada Herb. 81261); Lake Osoyoos, 31 May, 1905, *Macoun 69357* (Gray Herb.).

Montana: Big Fork, Flathead Co., 14 June, 1904, *W. W. Jones* (Mo. Bot. Gard. Herb.).

Washington: Fort Okanogan, U. S. Exploring Expedition, *Wilkes 971* (U. S. Nat. Herb. 48747).

71. S. multnomensis Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Ottawa Nat. **25**:115. 1911.

An herbaceous perennial, glabrous or slightly floccose-tomentulose in the axils of the leaves, on the margins of the petioles, and in the inflorescence; stems solitary or cespitose, erect or somewhat flexuous, 3 to 7 dm. high; lower leaves oblong-oblanceolate including the petiole 4 to 15 cm. long, .8 to 2 cm. broad, obtuse or rounded at the apex, crenate-dentate to more or less lyrately lobed with remote lobes and deep rounded sinuses, narrowed at the base into a slender petiole usually exceeding the blade; upper stem-leaves sessile and pinnatisect to much reduced entire bracts; inflorescence a ter-

minal few to many-headed corymbose cyme; heads 10 to 13 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre about 21, linear-lanceolate, 7 to 10 mm. long, usually pale green, glabrous or slightly floccose-tomentulose; ray-flowers 10 to 13, rays yellow; disk-flowers numerous, about 60; achenes glabrous.

Distribution: Mackenzie south to Saskatchewan, west to eastern Washington.

Specimens examined:

Mackenzie: Fort Smith, 4 Aug., 1901, *E. A. & A. E. Preble 172* (U. S. Nat. Herb.).

Saskatchewan: without definite locality, Palliser's British N. Am. Expl. Expedition, 1858, *E. Bourgeau* (Gray Herb.); Cypress Hills, province of Assiniboia, 24 June, 1894, *Macoun 5070* (Gray Herb. and U. S. Nat. Herb.).

Alberta: dry or rocky soil, Bow Valley, five miles west of Calgary, 14 June, 1913, *Moodie* (U. S. Nat. Herb.).

British Columbia: Kicking Horse Valley, vicinity of Field, alt. 1220 m., 20 June–25 July, 1906, *Brown 486, 487* (Phil. Acad. Nat. Sci. Herb.); Glacier, 30 July, 1901, *Williamson* (C. S. Williamson Herb.); cleared land at Howser Lake, alt. 610 m., 15 June, 1905, *Shaw 722* (U. S. Nat. Herb.); Trail, 10 June, 1902, *Macoun 64989* (Gray Herb.); Trail, 18 June, 1902, *Macoun 64992* (Gray Herb. and Mo. Bot. Gard. Herb.); rocky valley of Fraser River, above Yale, 22 July, 1880, *G. Engelmann* (Mo. Bot. Gard. Herb.).

Idaho: wet soil, Kootenai Co., alt. 900 m., July, 1900, *Leiberg* (Mo. Bot. Gard. Herb.).

Washington: Coleville Reservation, June, 1902, *Griffiths & Cotton 366* (U. S. Nat. Herb.).

Oregon: sandy flats, Cascades, 25 May, 1869, *Kellogg & Harford 537* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Multnomah Co., June, 1877, *T. J. Howell 221* (Gray Herb.), TYPE.

72. S. laetiflorus Greene, Pittonia **3**:88. 1896.

S. aureus var. *borealis* Eaton, in Bot. King's Exp. 190. 1871, not Torr. & Gray.

S. cymbalarioides var. *diversilobus* Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

An herbaceous perennial, glabrous, or in the early stages slightly white-flocculose-tomentulose and soon glabrate; stems 2 to 5 dm. high, simple or branched from the base; lower leaves petiolate, broadly ovate, elliptic-oblong to obovate, 1 to 6.5 cm. long, .5 to 4.5 cm. broad, entire to crenate-dentate, cuneate at the base and more or less decurrent on the petiole, thick and firm in texture; petioles 1.5 to 14 cm. long; stem-leaves sublyrate or irregularly pinnate-lobed with remote lobes, the uppermost sessile, semi-amplexicaul, often much reduced; inflorescence a few to many-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre (13–)21, linear-lanceolate, 5 to 8 mm. long, thickish, glabrous or at first slightly tomentulose and glabrate; ray-flowers about 13, rays pale yellow; disk-flowers numerous; achenes glabrous.

Distribution: Oregon, California, Idaho, and Nevada.

Specimens examined.

Oregon: moist meadows, Powder River Valley, alt. 1065 m., June–July, 1897, *Cusick 1617* (Gray Herb., U. S. Nat. Herb., Greene Herb., and Mo. Bot. Gard. Herb.); Otis Creek, alt. 1100 m., 19 June, 1896, *Leiberg 2324* (U. S. Nat. Herb.); near Devine ranch, alt. 1290 m., 27 June, 1896, *Leiberg 2411* (U. S. Nat. Herb.); Harney Valley, 29 May, 1885, *Th. Howell* (Gray Herb. and U. S. Nat. Herb.); near Silver Lake, alt. 1470 m., 20 Aug., 1894, *Leiberg 764* (Mo. Bot. Gard. Herb.), and *764a, 764b* (U. S. Nat. Herb.); Annie Creek, 8 Aug., 1897, *Mrs. R. M. Austin 1618* (U. S. Nat. Herb.).

California: near Boca, 26 July, 1895, *E. L. Greene* (Greene Herb.), TYPE; Gazelle, Siskiyou Co., 20 June, 1905, *Heller 8076* (U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Purdy, Sierra Co., 1 July, 1907, *Heller & Kennedy 8665* (U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Summit, *Bolander & Kellogg* (Gray Herb.); Sierraville, alt. 1525 m., *Hall & Babcock 4473* (Gray Herb.); Little Truckee River, alt. 2740 m., July, 1903,

Hall & Babcock 4526 (Gray Herb.); Sierra Nevada Mountains, coll. of 1875, *Lemmon* (U. S. Nat. Herb. 48715).

Nevada: Hunter Creek Cañon, Washoe Co., alt. 1830 m., 18 June, 1912, *Heller 10479* (U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.); Lemmon Valley, Washoe Co., alt. 1830 m., 8 July, 1913, *Kennedy 2066* (Mo. Bot. Gard. Herb.); Carson City, alt. 1525 m., 4 June, 1897, *M. E. Jones* (U. S. Nat. Herb. 359610); near Carson City, coll. of 1865, *Anderson* (Gray Herb.); Ruby Valley, alt. 1830 m., U. S. Geol. Expl. of the 40th Parallel, July, 1868, *Watson 670* (Gray Herb. and U. S. Nat. Herb.); without definite locality, coll. of 1872, *Lieut. Wheeler* (U. S. Nat. Herb. 48772).

Idaho: in patches on open slopes, Deer Creek, Owyhee Co., 1 July, 1912, *Nelson & Macbride 1850* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); moist sunny slopes, Three Creek, Owyhee Co., 1 July, 1912, *Nelson & Macbride 2247* (U. S. Nat. Herb.).

73. S. Suksdorfii Greenm. Bot. Gaz. **53**:511. 1912; Piper & Beattie, Fl. Northwest Coast 389. 1915.

S. Adamsi Howell, Fl. Northwest Am. **1**:379. 1900, not *S. Adamsii* Cheesem. Trans. N. Z. Inst. **28**:536. 1896; Piper, Contr. U. S. Nat. Herb. **11**:598. 1906.

An herbaceous perennial, slightly white-floccose-tomentulose in the leaf-axils and on the margins of the petioles near their base, otherwise glabrous; stems one to several from a rather stout rootstock, 1 to 2.5 dm. high; lower leaves petiolate, broadly ovate, 1 to 4 cm. long, 1 to 2.5 cm. broad, subtruncate to abruptly contracted to a cuneate base, crenate-dentate from base to apex, glabrous on both surfaces; petioles 1 to 5 cm. long; stem-leaves petiolate and sublyrate to sessile and more or less incised-dentate; inflorescence a few to several-headed corymbose cyme; heads 8 to 10 mm. high, radiate; ray-flowers 8 to 12, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: Washington to Nevada and California.

Specimens examined:

Washington: Mt. Adams (Paddo), alt. about 2155 m., 9 Aug., 1882, *Suksdorf 73* (Gray Herb., Geol. Surv. Canada

Herb., and Field Mus. Herb.); east of Mt. Adams (Paddo), Aug., 1892, *Henderson 2309* (Gray Herb.); Mt. Adams, alt. 1980 m., 25 July, 1899, *Flett* (U. S. Nat. Herb. 415519 in part); Indian Henry Park, Sept., 1909, *Tarleton 62* (Field Mus. Herb.).

Oregon: bases of granitic cliffs, source of the Imnaha, Wallowa Mountains, alt. 2690 m., Aug., 1906, *Cusick 3131* (U. S. Nat. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.).

Nevada: Mt. Rose, alt. 2940 m., 29 July, 1909, *Heller 9896* (U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., Field Mus. Herb., and Mo. Bot. Gard. Herb.).

California: wet mountain slopes at Lady Bug Peak, alt. 2440 m., 12 Aug., 1900, *Leiberg 5318* (U. S. Nat. Herb.).

74. S. rubricaulis Greene, Pittonia **3**:89. 1896.

S. aureus var. *croceus* Eaton in Bot. King's Exp. 190. 1871, not Gray, Proc. Acad. Phil. **15**:68. 1863.

S. Jonesii Rydb. Bull. Torr. Bot. Club **27**:179, *pl. 5, fig. 5.* 1900.

S. cymbalarioides Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains 582. 1909, as to *S. Jonesii* in synonymy.

An herbaceous perennial, glabrous or nearly so; stems erect, 3 to 4 dm. high; lower leaves petiolate, broadly ovate to obovate, 1 to 5 cm. long, 1 to 3 cm. broad, rather coarsely dentate, abruptly cuneate at the base, glabrous on both surfaces; petioles 1 to 7 cm. long, often purplish; stem-leaves petiolate and sublyrate to sessile and pinnatifid; inflorescence a terminal few to several-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre 13 to 21, linear-lanceolate, 5 to 7 mm. long, acute, glabrous, thickish, and in the later stages drying dark brown or blackish; ray-flowers 8 to 10, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: mountains of Utah, Wyoming, and Nevada.

Specimens examined:

Nevada: foothills of Clover Mountains, coll. of 1893, *E. L. Greene* (Greene Herb.), TYPE; Clover Mountains near Deeth, Elko Co., alt. 2000 m., 22 July, 1908, *Heller 9091* (Phil. Acad. Nat. Sci. Herb.).

Utah: Alta Wasatch Mountains, alt. 3350 m., 31 July, 1879, *M. E. Jones 1125* (Torrey Herb. and Field Mus. Herb.), TYPE of *S. Jonesii;* Wasatch Mountains, alt. 1525 m., May, 1869, *Watson 671* (Gray Herb.); Salt Lake City, alt. 1300 m., 15 July, 1880, *M. E. Jones 1996* (U. S. Nat. Herb.); Red Butte Cañon, Salt Lake Co., 12 July, 1906, *Garrett 1854, 1854a* (Field Mus. Herb.).

Yellowstone National Park: Electric Peak, alt. 2590 m., 26 July, 1902, *Sheldon 179* (U. S. Nat. Herb.); without definite locality, Aug., 1902, *Mearns 2671, 2719* (U. S. Nat. Herb.).

Var. **aphanactis** Greenm. var. nov.

Stem somewhat flexuous, at the base as well as the petioles more or less purplish; lower leaves rather coarsely and unequally dentate; heads about 1 cm. high, slightly nodding, discoid.

Distribution: Utah.

Specimen examined:

Utah: dry cañon, Logan, Cache Co., alt. 1525 m., 23 June, 1910, *C. P. Smith 2208* (Field Mus. Herb., photograph in Mo. Bot. Gard. Herb.), TYPE.

75. S. cymbalarioides Nutt. Trans. Am. Phil. Soc. N. S. **7**:412. 1841; Rydb. Mem. N. Y. Bot. Gard. **1**:446. 1900, in part; Bull. Torr. Bot. Club **27**:178. 1900, mainly; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Piper, Contr. U. S. Nat. Herb. **11**:598. 1906.

S. aureus var. *borealis* Torr. & Gray, Fl. N. Am. **2**:442. 1843, in part, i. e., *S. cymbalarioides* in synonymy; Gray, Syn. Fl. N. Am. 1^2:391. 1884, and ed. 2, 1886, in part.

S. aureus var. *obovatus* Eaton, in Bot. King's Exp. 190. 1871, not Torr. & Gray.

S. subcuneatus Rydb. Bull. Torr. Bot. Club **27**:179, *pl. 5. fig. 6.* 1900; Fl. Colo. 397. 1906.

An herbaceous perennial, glabrous except for a white-floccose tomentum in the axils of the leaves and on the base of the petioles; stems solitary or several from a common base, 1 to 3 dm. high; lower leaves petiolate, the blade broadly ovate, obovate to somewhat spatulate, 1 to 6 cm.

long, .5 to 3 cm. broad, entire or dentate towards the apex, glabrous on both surfaces, thick and firm in texture; petioles 1 to 8 cm. long; stem-leaves petiolate or sessile, incised-serrate to entire, the uppermost much reduced; inflorescence a few to several-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate, glabrous or rarely slightly tomentulose at the base; bracts of the involucre linear-lanceolate, 5 to 8 mm. long, thickish, in age drying dark brown or blackish and appearing somewhat glutinous; ray-flowers 8 to 12, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: Alberta and British Columbia, south to New Mexico and Nevada.

Specimens examined.

British America: Explorations in subarctic America, coll. of 1862, *Onion, Kennicott & Hardisty* (U. S. Nat. Herb.).

Montana: Duck Lake, 23 June, 1901, *Weller* (U. S. Nat. Herb.); hills and plains, Midvale, 17 and 24 June, 1903, *Umbach 78, 154* (U. S. Nat. Herb.); Little Belt Pass, alt. 2130 m., 10 Aug., 1896, *Flodman 910* (U. S. Nat. Herb.); near Red Lodge, 28 July, 1893, *Rose 79* (U. S. Nat. Herb.); Jack Creek Cañon, 15 July, 1897, alt. 2135 m., *Rydberg & Bessey 5265* (U. S. Nat. Herb.).

Yellowstone National Park: Swan Lake Flat, 30 July, 1902, *Sheldon 266* (U. S. Nat. Herb.); in open aspen groves, Yellowstone River, near Junction Butte, 10 July, 1899, *A. & E. Nelson 5823* (U. S. Nat. Herb., Gray Herb., and Mo. Bot. Gard. Herb.).

Wyoming: mountain sides, head of Middle Fork on Powder River, Big Horn Co., 19 July, 1901, *Goodding 302* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); grassy hillside, Ten Sleep Lakes, Big Horn Co., 30 July, 1901, *Goodding 414* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); northwestern Wyoming, 4 Sept., 1893, *Rose 683* (U. S. Nat. Herb.); flats near Holm Lodge, 28 June, 1911, *Reynolds 5* (Field Mus. Herb.); river bottoms, En-

campment, alt. 2195 m., 20 June, 1901, *Tweedy 4130* (U. S. Nat. Herb.).

Colorado: Grizzly Creek, 19 July, 1896, alt. 2590 m., *Baker* (Mo. Bot. Gard. Herb.), CO-TYPE of *S. subcuneatus.*

New Mexico: Baldy, 14 Aug., 1910, *Wooton* (U. S. Nat. Herb.).

Idaho: moranic ridge, south of Petit Lake, alt. 2195–2285 m., 14 Aug., 1895, *Evermann 330* (U. S. Nat. Herb.); Beaver Cañon, 28 June, 1895, *Shear 3028* (U. S. Nat. Herb.); timbered slopes, Mackay (Bear Cañon), Custer Co., alt. 2435 m., 31 July, 1911, *Nelson & Macbride 1510* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); four miles south of Ketchum, 23 July, 1895, *Henderson 3234* (U. S. Nat. Herb.); Henry's Lake and Mt. Chauvet, alt. 3050 m., 29 July, 1897, *Rydberg & Bessey 5267* (U. S. Nat. Herb. and Kew Herb.).

Utah: Wasatch Mountains, alt. 2135 m., June, 1869, *Watson 669* (Gray Herb.); Fish Lake, alt. 3050 m., 2 Aug., 1894, *Jones 57170* (U. S. Nat. Herb. 235767); Thousand Lake Mountain, alt. 3140 m., U. S. Geol. and Geog. Survey of the Territories, 13 July, 1875, *Ward 366* (U. S. Nat. Herb. 143111 in part).

Nevada: sagebrush flats, Mountain City, alt. 1830 m., 13 Aug., 1912, *Nelson & Macbride 2201* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); meadow, vicinity of Gold Creek, 6 Aug., 1913, *Hitchcock 1054* (U. S. Nat. Herb.).

Washington: south slope of Mt. Chapa, alt. 1220 m., Aug., 1897, *Elmer 592* (Mo. Bot. Gard. Herb. and Berlin Herb.); moist slopes, head of Prince Creek, alt. 1585 m., 2 Sept., 1897, *Gorman 809* (U. S. Nat. Herb.); coniferous woods, head of Twenty-five-mile Creek, alt. 1490 m., 10 Aug., 1897, *Gorman 810* (U. S. Nat. Herb.); slopes of Mt. Stuart, alt. 1065–1830 m., 24 July, 1893, *Sandberg & Leiberg 553* (Field Mus. Herb., Greene Herb., and Mo. Bot. Gard. Herb.), CO-TYPE of *S. fraternus;* Mt. Stuart, Kittitas Co., July, 1898, *Elmer 1384* (Mo. Bot. Gard. Herb.); Yakima Region, Northern Transcontinental Survey, coll. of 1883, *Brandegee 916* (Gray Herb.).

Oregon: "Columbia woods," *Nuttall* (Phil. Acad. Nat. Sci. Herb.); "R. Mts.," *Nuttall* (Gray Herb.); river bottoms, Union Co., coll. of 1881, *Cusick 928* (Gray Herb.); Cascade Mountains, alt. 1525 m., Oregon Boundary Commission, coll. of 1860, *Lyall* (Gray Herb.).

Var. **borealis** (T. & G.) Greenm. comb. nov.

S. aureus var. *borealis* Torr. & Gray, Fl. N. Am. **2**:442. 1843, excluding *S. cymbalarioides* Nutt.; Gray, Syn. Fl. N. Am. **1**[2]:391. 1884, and ed. 2, 1886, in small part; Macoun, Cat. Canadian Pl. 265. 1884, in part; Porter & Coulter, Syn. Fl. Colo. 81. 1874, in part; Coulter, Manual Rocky Mountain Region 211. 1885, in part.

S. aureus Hook. Fl. Bor. Am. **1**:333. 1834, in part, not L.

S. elongatus Howell, Fl. Northwest Am. **1**:379. 1900, as to *S. aureus* var. *borealis* in synonymy, not Pursh.

Stems slender, nearly naked above; lower leaves subspatulate to oblanceolate, including the petiole 1.5 to 6 cm. long, less than 1 cm. broad; in all other characters like the species into which it passes through several intermediate forms.

Distribution: Arctic America to Wyoming and Utah.

Specimens examined:

"Arctic America": *ex Herb. Hooker* (Gray Herb.).

Alberta: Fort Chipewyan, Athabasca, 5 June, 1903, *Preble & Cary 3* (U. S. Nat. Herb.); Peace River Landing, 13 June, 1903, *Macoun 61239* (Gray Herb.).

British Columbia: Skagit Valley, alt. 1220 m., 10 July, 1905, *Macoun 69362* (Gray Herb.).

Montana: Monida, 26 June, 1900, *Blankenship* (Gray Herb.).

Wyoming: head of Big Goose Creek, Big Horn Mountains, 15–24 July, 1893, *Tweedy 65* (U. S. Nat. Herb.).

Utah: Thousand Lake Mountain, alt. 3170 m., U. S. Geol. and Geog. Survey of the Territories, 13 July, 1875, *Ward 366* (Gray Herb. and U. S. Nat. Herb. 143111 in part).

Var. **streptanthifolius** (Greene) Greenm. comb. nov.

S. streptanthifolius Greene, Erythea **3**:23. 1895; Howell, Fl. Northwest Am. **1**:375. 1900.

Lower leaves suborbicular, obovate or oblong-obovate, somewhat glaucous.

Distribution: southeastern Idaho and northwestern Wyoming.

Specimens examined:

Idaho: Beaver Cañon, 1 Aug., 1889, *E. L. Greene* (Greene Herb.), TYPE; Beaver Cañon, 29 July, 1889, *E. L. Greene* (U. S. Nat. Herb.); northwestern Wyoming, 22 Aug., 1893, *Rose 243* (U. S. Nat. Herb.).

76. S. acutidens Rydb. Bull. Torr. Bot. Club **27**:180, *pl. 5, fig. 2.* 1900; Greenm. Monogr. Senecio, I. Teil, 23. 1901, and in Engl. Bot. Jahrb. **32**:19. 1902.

S. cymbalarioides Coulter & Nelson, Manual Cent. Rocky Mountains 582. 1909, in part, as to *S. acutidens* in synonymy; Wooton & Standley, Contr. U. S. Nat. Herb. **19**:747. 1915, as to specimen cited.

An herbaceous perennial, glabrous or slightly floccose-tomentulose in the early stages and soon glabrate except in the axils of the leaves; stems 1.5 to 2.5 dm. high, erect, more or less tufted, simple or branched; lower leaves obovate to oblong-oblanceolate, including the petiole 3 to 12 cm. long, .5 to 1.5 cm. broad, dentate towards the apex, entire towards the base and gradually narrowed into the petiole, thick and firm in texture, often bluish green and somewhat glaucous; stem-leaves oblanceolate and rather sparingly dentate to lance-attenuate and entire; inflorescence a terminal few to several-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre sparingly calyculate; ray-flowers 8 to 10, rays yellow; disk-flowers numerous; achenes glabrous or rarely slightly hirtellous along the angles.

Distribution: Wyoming to New Mexico.

Specimens examined:

Wyoming: Union Pass, Wind River Range, 10 Aug., 1894, *A. Nelson 858* (N. Y. Bot. Gard. Herb., Gray Herb., U. S.

Nat. Herb., Greene Herb., and Mo. Bot. Gard Herb.), TYPE; near Fort Bridger, coll. of 1873, *Pruddon* (Gray Herb.).

Colorado: Denver, Lieut. Wheeler's Expedition, 1873, *Wolf & Rothrock 558* (Gray Herb. and U. S. Nat. Herb.); Union Creek Pass, Lieut. Wheeler's Expedition, 1873, *Wolf & Rothrock 586* (U. S. Nat. Herb. and Gray Herb.).

New Mexico: Costilla Valley, alt. 3050 m., 5 Sept., 1913, *Wooton* (U. S. Nat. Herb.).

77. S. tridenticulatus Rydb. Bull. Torr. Bot. Club **27**:175. 1900; Fl. Colo. 396. 1906.

S. compactus (Gray) Rydb. Mem. Torr. Bot. Club **5**:342. 1894, not Kirk in Trans. N. Z. Inst. **12**:395. 1880; Heller, Cat. N. Am. Pl. 146. 1898, and ed. 2, 229. 1900; Britton & Brown, Ill. Fl. **3**:480, *fig. 4045.* 1898; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Britton, Manual 1028. 1901, and ed. 2, 1905.

S. aureus var. *compactus* Gray, Syn. Fl. N. Am. **1**^{2}:391. 1884, and ed. 2, 1886.

S. aureus var. *borealis* Gray, Pl. Wright., pt. 1, p.125. 1852, not Torr. & Gray.

S. oblanceolatus Rydb. Bull. Torr. Bot. Club **27**:175, *pl. 5, fig. 9.* 1900; Fl. Colo. 396. 1906; Wooton & Standley, Contr. U. S. Nat. Herb. **19**:747. 1915.

S. densus Greene, Pittonia **4**:226. 1900; Britton & Brown, Ill. Fl. **3**:546, *fig. 4631.* 1913.

S. condensatus Rydb. Fl. Colo. 396. 1906, not Greene.

S. mutabilis Nelson in Coulter & Nelson, Manual Cent. Rocky Mountains 583. 1909, mainly, not Greene.

S. manitobensis Greenm. Ottawa Nat. **25**:117. 1911, mainly.

S. suavis Lunell, Am. Mid. Nat. **2**:125. 1911.

S. Metcalfei Greene, Contr. U. S. Nat. Herb. **16**:193. 1913; Wooton & Standley, Contr. U. S. Nat. Herb. **19**:748. 1915.

S. remifolius Wooton & Standley, Contr. U. S. Nat. Herb. **16**:194. 1913.

An herbaceous perennial, glabrous or somewhat white-floccose-tomentulose and later glabrate except at the base and in the leaf-axils; stems one to several, frequently rather

densely tufted, 1 to 3 dm. high; lower leaves oblanceolate, entire, dentate towards the apex only or even pinnatisect, gradually narrowed at the base into a slender petiole, thick and firm in texture, including the petiole 2.5 to 10 cm. long, .5 to 1 cm. broad; upper stem-leaves becoming sessile and much reduced; inflorescence a terminal few to several-headed corymbose cyme; heads 8 to 10 mm. high, radiate; involucre campanulate, sparingly calyculate; bracts of the involucre 13 to 21, linear-lanceolate, 6 to 8 mm. long, glabrous; ray-flowers 10 to 12, rays yellow; disk-flowers numerous; achenes usually hirtellous on the ribs.

Distribution: Manitoba to Texas, and west to Nebraska, Colorado, and New Mexico.

Specimens examined:

Manitoba: sand hills at Brandon and Old Wives Lakes, 22 June, 1887, *Macoun 22* (Gray Herb.); on open prairie, south of Sewell, 12 June, 1876, *Macoun* (Geol. Surv. Canada Herb. 12232); gravelly or rocky places, Flat Creek, "N. W. T.," 20 June, 1880, *Macoun 103* (Geol. Surv. Canada Herb. 14796); Stewarts Lake Mountain, 21 June, 1875, *Macoun 14777* in part (Geol. Surv. Canada Herb.); north of Carberry, 14 June, 1906, *Macoun & Herriot* (Geol. Surv. Canada Herb. and Field Mus. Herb.); without definite locality, coll. of 1898, *E. S. Thompson* (Mo. Bot. Gard. Herb.).

North Dakota: on sand hills, McHenry Co., 13 July, 1899, *Lunell 24* (Gray Herb.).

South Dakota: Hot Springs, Fall River Co., 6 June, 1893, *Schenck* (Mo. Bot. Gard. Herb.).

Nebraska: Long Pine, 14 May and 4 June, 1893, *Rutter* (U. S. Nat. Herb.); sand hills on Middle Fork, Loup River, near Thedford, Thomas Co., 15 June, 1893, *Rydberg 1311* (Gray Herb. and U. S. Nat. Herb.); in dry sandy soil, Halsey, 1 and 2 June, 1903, *Mell & Knopf* (Mo. Bot. Gard. Herb.); Hershey, 20 May, 1903, *Mell 59* (U. S. Nat. Herb.); Franklin, coll. of 1893, *Labourne* (Mo. Bot. Gard. Herb.); Loup Fork, *Hayden* (Mo. Bot. Gard. Herb.).

Oklahoma: low places on prairie, near Camp, 12 May, 1913, *Stevens 420* (Mo. Bot. Gard. Herb.); without definite locality, *Stevens 489, 511* (G. W. Stevens Herb.).

Texas: on prairies, Amarillo, 19 May, 1902, *Reverchon 2523, 3330* (Mo. Bot. Gard. Herb.); prairies near Cañon City, June, 1901, *Eggert* (Mo. Bot. Gard. Herb.); Davis Mountains, 29 April, 1902, *Tracy & Earle 336* (Gray Herb., U. S. Nat. Herb., Greene Herb., and Mo. Bot. Gard. Herb.); "mountains beyond the Limpia," Expedition from western Texas to El Paso, May–October, 1849, *Wright 403* (Gray Herb.), TYPE.

Wyoming: open woods, Laramie Hills, Albany Co., 25 June, 1903, *A. Nelson 8962* (Mo. Bot. Gard. Herb.).

Colorado: near Greeley, June, 1908, *E. L. Johnston 461, 463, 466* (Mo. Bot. Gard. Herb.); dry plains, near Evans, colls. of 1907–1909, *E. L. Johnston 423, 423a, 424, 442, 443, 537, 538, 551, 552* (Mo. Bot. Gard. Herb.); Evans, 8 June, 1912, *E. L. Johnston 804* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); in river bottoms, Fort Lupton, 19 May, 1913, *E. L. Johnston 882, 883, 875* (U. S. Nat. Herb.); Clear Creek, Hayden's U. S. Geol. Survey, 20 May, 1873, *Coulter* (Phil. Acad. Nat. Sci. Herb.), in part; Lat. 39–41°, coll. of 1864, *Parry* (U. S. Nat. Herb. 349250); Lat. 39–41°, coll. of 1862, *Hall & Harbour 333* in part (Gray Herb. and Field Mus. Herb.); Denver, May, 1881, *B. H. Smith* (Phil. Acad. Nat. Sci. Herb.); Denver, May, 1889, *Eastwood* (U. S. Nat. Herb.); Denver, 8 June, 1891, *E. C. Smith* (Mo. Bot. Gard. Herb.); Denver, *Williamson* (C. S. Williamson Herb.); dry ground, Middle Creek, July, 1892, *Beardslee 60* (U. S. Nat. Herb.); near Breckenridge, Summit Co., alt. 2950 m., *Mackenzie 112* (Mo. Bot. Gard. Herb.); pasture land, Como, alt. 3050 m., 1 Aug., 1895, *Crandall & Cowen 280* (U. S. Nat. Herb.); Leadville, *H. A. Keller* (Phil. Acad. Nat. Sci. Herb.); Leadville, 8 July, 1886, *Trelease* (Mo. Bot. Gard. Herb.); wet sandy places, along Cottonwood Creek, Buena Vista, Chaffee Co., alt. 2425–2440 m., 4 July, 1892, *Sheldon 161, 479* (U. S. Nat. Herb.); open gravel bank, near railway station,

Limon, Lincoln Co., 13 June, 1912, *Churchill* (J. R. Churchill Herb.); Colorado Springs, May, 1879, *M. E. Jones* (U. S. Nat. Herb. 223024 in part); Colorado Springs, alt. 1830 m., 8 May, 1897, *A. A. & E. G. Heller 3508* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Colorado Springs, May, 1892, *Mulford* (Mo. Bot. Gard. Herb.); Colorado Springs, 2 Aug., 1891, collector not indicated (Mo. Bot. Gard. Herb.); Pike's Peak, 10 July, 1901, *Williamson* (C. S. Williamson Herb.); plains near Westcliffe, Custer Co., 25 July, 1887, *Demetrio* (Gray Herb.); Colorado Springs, 10 May, 1882, *Allen & Brewster* (U. S. Nat. Herb. and Gray Herb.); saline soil on the plains, 12 May, 1870, *Greene* (Gray Herb.); Veta Pass, Sangre de Cristo Range, alt. 2740–3350 m., 9–16 June, 1890, *Mr. & Mrs. G. H. Hicks 9* (Gray Herb.); Veta Pass, 15 July, 1896, *Sheldon 3622* (U. S. Nat. Herb.); Pagosa Springs, 3 June, 1883, *B. H. Smith* (Phil. Acad. Nat. Sci. Herb.); southwestern Colorado, Hayden's U. S. Geol. Survey, 1875, *Brandegee* (Mo. Bot. Gard. Herb.); wet mountain valley, July, 1885, *Kettler* (Gray Herb.); in dry fields, Mancos, alt. 2135 m., 8 July, 1898, *Baker, Earle & Tracy 446* (Mo. Bot. Gard. Herb.); Rocky Mountains, coll. of 1888. *Tracy* (U. S. Nat. Herb. 48706).

Nevada: eastern Nevada, coll. of 1883, *Meehan* (Phil. Acad. Nat. Sci. Herb.).

New Mexico: dry hills, vicinity of Raton, Colfax Co., alt. 2100–2380 m., 21–22 June, 1911, *Standley 6278* (U. S. Nat. Herb.); upland slopes, Catskill, June–July, 1895, *Mrs. O. St. John 139* (Gray Herb.); plains on and near the Sierra Grande, Union Co., alt. 2100–2935 m., 19 June, 1911, *Standley 6123* (U. S. Nat. Herb.); along the river and in damp meadow, vicinity of Chama, Rio Arriba Co., alt. 2380–2850 m., 8 and 9 July, 1911, *Standley 6532, 6734* (U. S. Nat. Herb.); pass southeast of Tierra Amarilla, Rio Arriba Co., alt. 2300 m., 18 April–25 May, 1911, *Eggleston 6531, 6595* (U. S. Nat. Herb.); Hillsboro Peak, Grant Co., alt. 3100 m., 27 May, 1904, *Metcalfe 938* (U. S. Nat. Herb., Gray Herb., and Mo. Bot. Gard. Herb.), TYPE of *S. Metcalfei*; Willow

Creek, 8 Aug., 1908, *Wooton* (U. S. Nat. Herb.), TYPE of *S. remifolius*.

78. S. Wardii Greene, Pittonia **4**:116. 1900; Heller, Cat. N. Am. Pl. 231. 1900. Pl. 3, fig. 3.

A low herbaceous perennial, glabrous or slightly tomentulose in the leaf-axils; stems tufted, erect, less than 1 dm. high; lower leaves oblong-oblanceolate including the petiole 1.5 to 4 cm. long, 3 to 10 mm. broad, entire or dentate towards the obtuse or rounded apex; stem-leaves few, more or less bracteiform; inflorescence a terminal round-topped rather dense cyme; heads 6 to 8 mm. high, radiate; involucre campanulate, sparingly calyculate, glabrous or nearly so; bracts of the involucre about 13, linear-lanceolate, 4 to 5 mm. high; ray-flowers 8 to 10, rays yellow; disk-flowers numerous; achenes glabrous.

Distribution: high mountains of Utah.

Specimens examined:

Utah: Fish Lake Mountain, and Thousand Lake Mountain, alt. about 3500 m., U. S. Geol. and Geog. Survey of the Territories, 8 July, 1875, *Ward 332* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.), TYPE. This species may be looked for in herbaria under *S. aureus* var. *alpinus* under which name it was distributed.

79. S. anacletus Greene, Pittonia **4**:307. 1901; Rydb. Fl. Colo. 395. 1906; Coulter & Nelson, Manual Cent. Rocky Mountains 579. 1909. Pl. 4.

S. microdontus (Gray) Heller, Bull. Torr. Bot. Club **24**:479. 1897, not Baker; Cat. N. Am. Pl. 146. 1898, and ed. 2, 230. 1900; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902; Wooton & Standley, Contr. U. S. Nat. Herb. **19**:746. 1915.

S. Toluccanus var. *microdontus* Gray, Syn. Fl. N. Am. 1^2:388. 1884, and ed. 2, 1886.

S. Wootonii Greene, Bull. Torr. Bot. Club **25**:122, *pl. 331, figs. 1, 2.* 1898.

An herbaceous perennial, glabrous throughout and usually glaucous; stems one to several from an ascending fibrous-

rooted rather stout rootstock, simple or branched, erect, 2 to 5 dm. high; lower leaves obovate to oblong-oblanceolate, including the petiole .5 to 2.5 dm. long, .5 to 4.5 cm. broad, thick and firm in texture, rounded to submucronate-acute at the apex, entire to sinuate-denticulate, gradually narrowed at the base into a slightly winged petiole; stem-leaves few, oblanceolate to lance-attenuate, sessile and entire; inflorescence terminating the stem and branches in a simple or compound corymbose cyme; heads 10 to 12 mm. high, radiate; involucre campanulate, calyculate; bracts of the involucre about 13, linear-lanceolate, 7 to 9 mm. long, acute, glabrous except at the brownish penicillate tips; ray-flowers 8 to 10, rays yellow; disk-flowers numerous; achenes striate, glabrous.

Distribution: Colorado to northern Mexico.

Specimens examined:

Colorado: pine woods below Berthoud's Pass, alt. 3200 m., 10 Aug., 1874, *G. Engelmann* (Mo. Bot. Gard. Herb.); summit of steep mountains, Estes Park, alt. 3050 m., 7 July, 1912, *Churchill* (J. R. Churchill Herb.); Tolland, alt. 2740 m., 23 July, 1913, *Overholts* (Mo. Bot. Gard. Herb.); damp places in the valley near Empire, alt. about 3050 m., 21 July, 1892, *Patterson 199* (Gray Herb.); valley near Empire, alt. 2590 m., July, 1892, *Patterson 202* (Mo. Bot. Gard. Herb.); Breckenridge, coll. of 1887, *Bereman* (Mo. Bot. Gard. Herb.); Redcliff, Eagle Co., 17 July, 1902, *Osterhout 2704* (Phil. Acad. Nat. Sci. Herb.); Leadville, 6 July, 1886, *Trelease* (Mo. Bot. Gard. Herb.); "Sawatch" Range, alt. 3350 m., Aug., 1880, *Brandegee* (Gray Herb. and Mo. Bot. Gard. Herb.); head waters of Clear Creek, etc., coll. of 1861–62, *Parry 21* (Gray Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Lat. 39–41°, *Hall & Harbour 326* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Taylor River, alt. 2895 m., Hayden's U. S. Geol. Survey, 3 Aug., 1873, *Porter* (U. S. Nat. Herb.); meadows, South Cottonwood Gulch, Chaffee Co., alt. 3200 m., 9 July, 1892, *Sheldon 169, 488* (U. S. Nat. Herb.); Silverton,

July, 1889, *Eastwood* (U. S. Nat. Herb.); Silverton, alt. about 2895 m., 3 and 16 July, 1898, *ex Herb. Colorado State Agr. Coll. 3097, 3117* (U. S. Nat. Herb.); Pagosa Springs, 4, June, 1894, *B. H. Smith* (Phil. Acad. Nat. Sci. Herb.); Little Kate Mine, La Plata Mountains, alt. 3352 m., 16 July, 1898, *Baker, Earle & Tracy 552* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); La Plata River, 16 July, 1898, *Baker, Earle & Tracy 994* (Mo. Bot. Gard. Herb.); Rocky Mountains, coll. of 1868, *Vasey* (U. S. Nat. Herb.).

New Mexico: pass south of Tierra Amarilla, Rio Arriba Co., alt. 2320 m., 18 April–25 May, 1911, *Eggleston 6530, 6617* (U. S. Nat. Herb.); pine woods, vicinity of Brazos Cañon, Rio Arriba Co., 21 Aug., 1914, *Standley & Bollman 10676* (U. S. Nat. Herb.); Rio de la Casa, above Mora, 30 May–1 June, 1902, *Sturgis* (Gray Herb.); valley of Santa Fé Creek, at the foot of mountains, ten miles above Santa Fé, coll. of 1847, *Fendler 477 (437)* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.); Sante Fé Cañon, nine miles east of Santa Fé, alt. 2440 m., 2 June, 1897, *A. A. & E. G. Heller 3648* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.); Hermit's Peak, San Miguel Co., Aug., 1884, *F. H. Snow* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Rio Pecos, three miles above Winsor's, alt. about 2650 m., 30 June, 1908, *Standley 4083* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); White Mountains, Lincoln Co., alt. 2130 m., 15 Aug., 1897, *Wooton* (U. S. Nat. Herb., Greene Herb., fragment in Mo. Bot. Gard. Herb.), TYPE of *S. Wootonii;* White Mountains, Lincoln Co., alt. 2255 m., 25 Aug., 1907, *Wooton & Standley 3510* (U. S. Nat. Herb.); Cloudcroft, Otero Co., alt. 2590 m., 29 May–5 June, 1902, *Viereck* (Phil. Acad. Nat. Sci. Herb.); James Cañon, Sacramento Mountains, Otero Co., 26 June, 1899, *Wooton* (U. S. Nat. Herb.); Pinos Altos Mountains, 21 May, 1880, *E. L. Greene* (Gray Herb.); Pinos Altos, 15 Aug., 1895, *Mulford 881* (Mo. Bot. Gard. Herb.).

Arizona: San Francisco Mountains, coll. of 1884, *Lemmon 3264* (Gray Herb.); San Francisco Mountains, alt. 2135–

2440 m., 22 June, 1891, *McDougal 253* (U. S. Nat. Herb.); Kendrick Peak, near Flagstaff, May–Oct., 1900, *Purpus 8001* (Mo. Bot. Gard. Herb.); near Flagstaff, alt. 1850 m., 16 Aug., 1901, *Leiberg 5859* (U. S. Nat. Herb.); Apache-Verde, east of Baker Butte, Black Mesa Forest Reserve, 1 June, 1900, *Coville 1040* (U. S. Nat. Herb.); Santa Catalina Mountains, alt. 2740 m., April, 1881, *Lemmon 190* (Gray Herb.); Rincon Mountains, alt. 2285 m., coll. of 1891, *Neally 221* (U. S. Nat. Herb.); Santa Rita Mountains, alt. 2135–2440 m., 3 May, 1881, *Pringle* (Gray Herb., U. S. Nat. Herb., and Phil. Acad. Nat. Sci. Herb.); in pine forests, Santa Rita Mountains, alt. 2285 m., 8 June, 1884, *Pringle* (Phil. Acad. Nat. Sci. Herb.); Tanner's Cañon, near Fort Huachuca, coll. of 1882, *Lemmon 2786* (Gray Herb.); Willow Spring, 10–20 June, 1890, *Dr. E. Palmer 479* (Gray Herb. and U. S. Nat. Herb.); Ramsey Cañon, Huachuca Mountains, 10 April, 1915, *Blumer 5929* (Mo. Bot. Gard. Herb.); rolling andesitic pine land, Barfoot Park, Chiricahua Mountains, alt. 2440–2500 m., 17 Sept., 1906, *Blumer 151, 1388* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.).

Chihuahua: Colonia Garcia in the Sierra Madres, alt. 2285 m., 6 June, 1899, *Townsend & Barber 14* (Gray Herb. and Mo. Bot. Gard. Herb.).

80. S. toluccanus DC. Prodr. **6**:428. 1837; Schz. Bip. in Seemann, Bot. Voy. Herald 311. 1852–57; Hemsl. Biol. Cent.-Am. Bot. **2**:248. 1881; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902. Pl. 5.

An herbaceous perennial; stems 2 to 10 dm. high, erect or ascending from a thick stout rootstock; lower leaves ovate to oblong-oblanceolate, including the petiole 5 to 30 cm. long, 1 to 10 cm. broad, acute or obtuse, slightly crenate to conspicuously dentate with spreading subcartilaginous teeth, narrowed at the base into a winged petiole, thick and firm in texture, glabrous on both surfaces or slightly tomentulose in the early stages and soon glabrate; stem-leaves few, sessile and semi-amplexicaul, lanceolate, dentate to entire; inflorescence terminating the stem in a

few to many-headed glabrous or somewhat pubescent corymbose cyme; heads 10 to 15 mm. high, radiate; involucre campanulate, calyculate; bracts of the involucre 13 to 21, linear-lanceolate, 7 to 9 mm. long, glabrous or nearly so; ray-flowers 10 to 12, rays yellow; disk-flowers numerous; achenes striate, glabrous.

Distribution: Mexico.

Specimens examined:

Coahuila: south of Saltillo, Feb.–Oct., 1880, *Dr. E. Palmer* (Gray Herb.).

San Luis Potosi: Valley of San Luis Potosi, Aug., 1876, *Schaffner 277* (Gray Herb. and U. S. Nat. Herb.); Valley of San Luis Potosi, alt. 1830–2440 m., *Parry & Palmer 537* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.).

Jalisco: Nevada de Colima, alt. 3050–3650 m., 16 May, 1893, *Pringle 4374* (Gray Herb., U. S. Nat. Herb., and Mo. Bot. Gard. Herb.).

Michoacan: north slope of Mt. Patambau, alt. 2895–3350 m., 1–4 Feb., 1903, *E. W. Nelson 6598* (U. S. Nat. Herb.).

Mexico: Sierra de las Cruces, 11 Sept., 1892, *Pringle 5261* (Gray Herb.); Nevada de Toluca, 15 Oct., 1903, *Rose & Painter 7901* (Gray Herb.).

Federal District: Serrania de Ajusco, alt. 3050 m., 16 April, 1898, *Pringle 6812* (Gray Herb., U. S. Nat. Herb., Phil. Acad. Nat. Sci. Herb., and Mo. Bot. Gard. Herb.).

Southern Mexico: "cuesta de las papao pr. Angangueo", Feb., 1830, *Schiede* (Berlin Herb., Gray Herb., and U. S. Nat. Herb.); wet places on Mt. Ixtaccihuatl, alt. 2740–3050 m., Nov., 1905, *Purpus 1509* (U. S. Nat. Herb. and Mo. Bot. Gard. Herb.); Mt. Orizaba, 21 April, 1893, *E. W. Nelson 5* (U. S. Nat. Herb.); Mt. Orizaba, alt. 4025–4265 m., 18 March, 1894, *E. W. Nelson 281* (U. S. Nat. Herb.); wet grassy soil near timberline, Mt. Orizaba, March, 1908, *Purpus 2976* (U. S. Nat. Herb.); "Vera Cruz," *Galeotti 2183* (Kew Herb.); at the base of Jacal (Joerl), June, 1839, *Ehrenberg 1294* (Berlin Herb. and Gray Herb.); in woods near Guapi-

malpam, coll. of 1854, *Schaffner* (Gray Herb.); without definite locality, coll. of 1848–1849, *Gregg 690* in part (Mo. Bot. Gard. Herb.).

Var. **modestus** Schz. Bip. in Seemann, Bot. Voy. Herald 311. 1852–57; Hemsl. Biol. Cent.-Am. Bot. **2**:248. 1881; Greenm. Monogr. Senecio, I. Teil, 24. 1901, and in Engl. Bot. Jahrb. **32**:20. 1902.

Stems slender, 3 to 4 dm. high, nearly naked above; lower leaves oblanceolate, 3 to 14 cm. long, .5 to 1.5 cm. broad.

Distribution: northwestern Mexico.

Specimens examined:

Northwest Mexico: Sierra Madre, *Seemann* (Kew Herb. and Gray Herb.).

Chihuahua: Mound Valley, south of Pacheco, 12 June, 1891, *Hartman 690* (Gray Herb. and Mo. Bot. Gard. Herb.).

(To be continued.)

Explanation of Plate

PLATE 3

Fig. 1. *Senecio Rosei* Greenm.
Mexico

From the type specimen, Rose No. 2157, in the Gray Herbarium of Harvard University.

Fig. 2. *Senecio Wardii* Greene
Utah

From a co-type specimen, Ward No. 332, in the Gray Herbarium of Harvard University.

Fig. 3. *Senecio hesperius* Greene
Oregon

From Howell's No. 160 in the Gray Herbarium of Harvard University.

GREENMAN—MONOGRAPH OF SENECIO

Explanation of Plate

PLATE 4

Senecio anacletus Greene
United States

From Heller's No. 3648 in the Herbarium of the Missouri Botanical Garden.

Explanation of Plate

PLATE 5

Senecio toluccanus DC.

Mexico

From Pringle's No. 6812 in the Gray Herbarium of Harvard University.

NEW OR INTERESTING SPECIES OF GILL FUNGI FROM MISSOURI

L. O. OVERHOLTS

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The following collections of gill fungi made by the writer in the vicinity of St. Louis, Missouri, within the past two years are believed to be undescribed.

Claudopus subnidulans Overholts, n. sp.

Pileus sessile, reniform or dimidiate in outline, convex, 0.5–2 cm. broad, bright tawny orange, fibrillose-tomentose, dry; margin inrolled, even or very slightly striate; flesh thin, white; odor and taste none; gills radiating outward from the point of attachment of the pileus, medium distant, rather broad (3–5 mm.), salmon-colored or dull orange; stem none, the pileus attached by a white tomentose base; spores salmon-colored, globose, smooth, 5–7μ broad; cystidia none.

On rotten logs in damp woods. Jefferson Barracks, near St. Louis, Missouri, October 25, 1913.

Type collection in Herb. Overholts No. 1460, and specimens from this collection are deposited in the herbarium of the Missouri Botanical Garden.

The species resembles *C. nidulans*, but differs in the constantly smaller size and the exactly globose spores.

Panaeolus reticulatus Overholts, n. sp. Plate 6, fig. 1.

Pileus hemispheric then expanded, sometimes somewhat umbonate, 3.5–6 cm. broad, between drab and light brownish umber when young, usually smoky brown or blackish with age, dry, everywhere pitted or when older appearing fibrous-recticulate; the margin even, at first incurved then wavy; flesh thin, watery, pallid; taste and odor not characteristic; gills broadly attached but sometimes sinuate, often separating with age, spotted, or in age uniformly black, rather close,

unequal, 4–7 mm. broad, the edge whitish; stem central, terete, equal or slightly tapering downward, hollow, twisted, pruinose-scabrous at the apex, somewhat shining, pale brown, cartilaginous and brittle, 4–8 cm. long, 4–8 mm. thick; veil not apparent; spores elliptic or broadly elliptic, nearly black, 8–10×5.5–6.5μ; cystidia none.

Cespitose or gregarious on earth in flower beds in the Missouri Botanical Garden, May 31, 1915; also at the same place, June 17, 1915.

Type collection in Herb. Overholts No. 2795, and specimens from this collection are deposited in the herbaria of the New York Botanical Garden and the Missouri Botanical Garden.

The species is in every way distinct from *P. retirugis* Fries and *P. alveolatus* Peck. The pileus when very young is pitted only in the center, but mature plants are pitted all over and at times appear reticulate. When dried the pileus is smooth or nearly so.

Panaeolus rufus Overholts, n. sp. Plate 6, fig. 2.

Pileus convex to nearly plane, sometimes broadly umbonate, 2–5 cm. broad, varying in color from tan to light brown or chestnut, darkest at the center, dry, glabrous, often becoming cracked and areolate except at the center; margin even, extending slightly beyond the lamellae; flesh thin, white; odor none; taste farinaceous; gills adnate or adnexed, medium close or slightly distant, spotted, becoming blackish brown, whitish on the edge; stem central, terete, pruinose, striate, light-colored above, becoming dark reddish brown below, white tomentose at the base, firm, cartilaginous, hollow, 5–10 cm. long, 2.5–6 mm. thick; veil not apparent; spores elliptic or broadly elliptic, almost black in mass, 12–13.5×7.5–9μ; cystidia none.

Gregarious on a compost heap in the Missouri Botanical Garden, June 1, 1915.

Type collection in Herb. Overholts No. 2796, and specimens from this collection are deposited in the herbaria of the Missouri Botanical Garden and the New York Botanical Garden.

The plants are more highly colored than in any described species of *Panaeolus.*

Panaeolus variabilis Overholts, n. sp. Plate 6, figs. 3, 4.

Pileus slightly campanulate to convex or plane, young specimens indistinctly umbonate, 2–6 cm. broad, very variable, when young hygrophanous, fleshy brown mingled with gray, somewhat rugose, when mature dry and lighter or creamy white, glabrous; margin even; flesh thin, concolorous; odor none; taste slightly farinaceous; gills adnate to adnexed, at first light brown, then spotted, finally black, rather close, 3–6 mm. broad, whitish on the edge; veil none; stem central, terete, equal or nearly so, pallid to slightly flesh-color or dark brown, floccose-pruinose when young, usually striate at the apex, hollow from the first, 4–9 cm. long, 2–5 mm. thick; spores broadly eliptic or ellipsoid, black, 12–13×7–9μ; cystidia none.

Gregarious or subcespitose on earth in flower beds and among shrubbery in the Missouri Botanical Garden, May 31, 1915; also from the same place, June 17, 1915.

Type collection in Herb. Overholts No. 2794, and specimens from this collection are deposited in the herbaria of the Missouri Botanical Garden and the New York Botanical Garden. The species is a very variable one.

AN INTERESTING VARIETY OF PLUTEUS CERVINUS

In November, 1914, while collecting in the region of Pacific, Missouri, the writer found a large cluster of a species of *Pluteus* growing in the sawdust on an old sawmill site. There were about thirty individuals in the cluster, and they ranged from 11 to 16 cm. broad. The specimens were much larger than is usual in *Pluteus cervinus,* and the fibrils on the pileus were much more conspicuous than in that species. These facts, together with the cespitose habit and another character mentioned below, seemed to justify the separation of these specimens into a new species. Further study has led the writer to modify this first conclusion, and the plants are now referred to *P. cervinus.* The variations are so marked, however, that they deserve notice, the accompanying

figures showing these points. For convenience this collection will be referred to below under my herbarium number, 2316.

A microscopic examination of the hymenium of this and other collections of *P. cervinus* reveals some interesting variations in the form of the cystidia. These are more or less flask-shaped structures and hyaline. The accompanying figures show the variations. In all collections examined (except the one referred to above) some of the cystidia have peculiar thorn-like projections more or less abundant. Figure *A* is from my herbarium, No. 2809, and in most collections it is probably the most typical form present. Figures *B*, *C*, and *D* are from my herbarium, No. 1624, and the thorny type

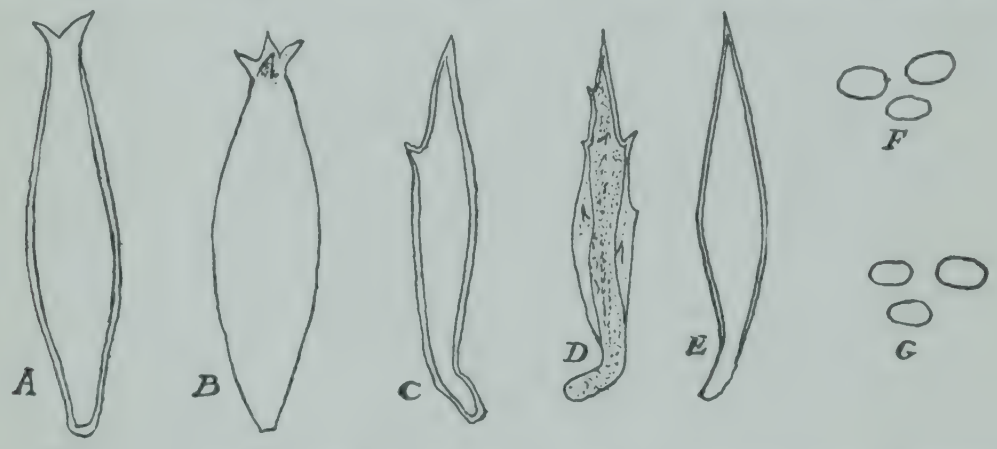

Fig. 1. Various types of cystidia found in hymenium of *Pluteus cervinus: A*, from herbarium No. 2809; *B*, *C*, and *D*, from herbarium No. 1624, the thorny type *D* being most abundant; *E*, cystidium of *P. cervinus* var. *caespitosus*. (This type is also present in other collections.) *F*, spores of *P. cervinus; G*, spores of *P. cervinus* var *caespitosus*.

of cystidium was better developed in that collection than in any other one examined. These sharp projections were most often not present on the apex of the cystidium, but were scattered along the sides as thorns on a stem. In both collections cited and in all others examined there were present also a large number of entirely smooth, sharp-pointed cystidia. When collection No. 2316 was examined no cystidia with thorny projections were seen. It is very doubtful whether this is a constant character on which, together with other beforementioned facts, a new species might be segregated. However, there are certainly no such cystidia present as in the other collections; but the presence in other collections of en-

tirely smooth cystidia seems to bridge over the gap in this respect, and it seems best at present to regard this latest collection as only a variety of *Pluteus cervinus.*

P. petasatus Fries, sometimes regarded as a synonym of *P. cervinus,* approaches this collection in size and is reported as growing on sawdust, but it is described as glabrous and commonly umbonate—characters that do not apply to my plants. For convenience the present collection may be designated as follows:

Pluteus cervinus var. **caespitosus** Overholts, n. var.
Plate 6, figs. 5, 6.

Pileus 11–16 cm. broad, very slightly viscid, decorated with brownish fibrils or appressed, fibrillose scales that are more prominent in the center; gills 1–1.7 cm. broad; stem 10–15 cm. long, 1.3–2.5 cm. thick; spores oblong-ellipsoid, smooth, hyaline under the microscope, salmon-colored in mass, 4–7×3–4μ; cystidia abundant, fusiform, sharp-pointed, smooth, 40–75×10–12μ.

On heap of sawdust. Densely cespitose in a cluster of about thirty plants. Pacific, Missouri, November 9, 1914.

Type collection in Herb. Overholts No. 2316, and a single specimen from the collection has been deposited in the herbarium of the Missouri Botanical Garden. The variety is edible and quite delicious.

Explanation of Plate

PLATE 6

Fig. 1. *Panaeolus reticulatus.* From photograph of type specimen in Herbarium Overholts No. 2795.

Fig. 2. *Panaeolus rufus.* From photograph of type specimen in Herbarium Overholts No. 2796.

Figs. 3 and 4. *Panaeolus variabilis.* From photographs of type specimen in Herbarium Overholts No. 2794.

Figs. 5 and 6. *Pluteus cervinus* var. *caespitosus.* From photographs of type specimen in Herbarium Overholts No. 2316.

OVERHOLTS—GILL FUNGI